Laying the Foundation for a Bright Future

Assessing Progress Under Phase 1 of India's National Solar Mission

Interim Report: April 2012



Prepared by

Council on Energy, Environment and Water
Natural Resources Defense Council

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ABOUT THIS REPORT

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The Council on Energy, Environment and Water (CEEW) is an independent nonprofit policy research institution that works to promote dialogue and common understanding on energy, environment, and water issues in India and elsewhere through high-quality research, partnerships with public and private institutions and engagement with and outreach to the wider public. (http://ceew.in).

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The Natural Resources Defense Council (NRDC) is an international nonprofit environmental organization with more than 1.3 million members and online activists. Since 1970, our lawyers, scientists, and other environmental specialists have worked to protect the world's natural resources, public health, and the environment. NRDC has offices in New York City; Washington, D.C.; Los Angeles; San Francisco; Chicago; Livingston and Beijing. (www.nrdc.org).

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Neither CEEW nor NRDC has commercial interests in India's National Solar Mission, nor has either organization received any funding from any commercial or governmental institution for this project.

Acknowledgments
The authors of this report thank government officials from India's Ministry of New and Renewable Energy (MNRE), NTPC Vidyut Vyapar Nigam (NVVN), and other Government of India agencies, as well as United States government officials. We would also like to thank former MNRE Secretary Deepak Gupta. We are grateful to the solar developers, financial institutions, solar manufacturers, solar energy experts, academics, and community members who shared their feedback and helped inform the findings of this report. The authors would also like to thank the following people, who acted as peer reviewers, for their valuable insights: Pierre Bull, Suman Kumar, Peeyush Mohit, Rana Mookherjee, Rajesh Peddu, P. Ramana Reddy, A. P. Shrivastava, Ashish Shrotriya, Cai Steger, and Atul Vijaykar. We would especially like to thank Shakti Sustainable Energy Foundation and our other funders for their generous support. This report is supported, in part, by Shakti Sustainable Energy Foundation. The views expressed and analysis in this document do not necessarily reflect views of the Foundation. The Foundation does not guarantee the accuracy of any data included in this publication nor does it accept any responsibility for the consequences of its use.

Scope of Report
This report focuses on the Jawaharlal Nehru National Solar Mission's objectives, targets, and incentives for grid-connected solar photovoltaic (PV) projects in India. The Mission's goals relating to solar thermal and off-grid solar projects are not covered in this report.

Methodology
This report adopts a whole-of-system approach by focusing on various public and private institutions operating in the solar ecosystem, the record and challenges of commissioning projects, the bankability of projects, the building of a robust manufacturing base, and analysis of the related enabling environment for the industry. The process included initial identification of key solar stakeholders in India and internationally to understand stakeholder perspectives and barriers to effective implementation of the National Solar Mission. Primary research was conducted through extensive discussions during in-person meetings, phone conversations, and written communication, and during conferences and workshops, including SOLARCON and Intersolar 2011. The organizations also engaged periodically with the Ministry of New and Renewable Energy as well as other government agencies to understand their approaches, innovations, and concerns about the Solar Mission.

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FOREWORD

India is blessed with abundant sunshine, in fact 300 days' worth in most regions. Average incident solar radiation ranges between 4 and 7 kilowatt-hour per day per square metre – much higher than the amount of solar radiation in many other countries. Meanwhile, 70 percent of India's primary energy supply relies on fossil fuels while hundreds of millions of people need access to modern sources of energy. In 2010 India launched the Jawaharlal Nehru National Solar Mission, one of the world's largest solar energy programmes. The aim is to install 20000 megawatts (MW) of grid-connected solar power and 2000 MW of off-grid solar power by 2022. This is an ambitious mission with the promise of responding, in part, to India's climate challenge and to increasing energy access. Like India, most of the solar potential world over is in tropical countries. But by one count, until 2010, eight of the top ten countries with installed solar photovoltaic capacity were in temperate zones. Clearly, there is a long way to go before India realises its potential in solar energy but the National Solar Mission has positioned itself to play a significant catalytic role. How it could do so is the subject of this report.

A nascent solar industry is beginning to take shape in India, with more than 500 MW of capacity installed already. Competitive bids for projects have also driven prices for solar power down rapidly. But installed capacity and prices do not complete the picture. There is a need to understand challenges in installing projects, so that developers are able to do so on time and feed electricity into the grid at committed capacities. There are also questions about choice of technology and policies related to sourcing cells, modules and other equipment. And, perhaps most importantly, solar projects have to be financially viable to attract the levels of investment necessary to meet the Mission's targets. These issues are interconnected and interdependent, critical to the evolution of a solar ecosystem.

In order to examine all the dimensions of the ecosystem, the Council on Energy, Environment and Water (CEEW) and the Natural Resources Defense Council (NRDC) partnered to produce *Laying the Foundation for a Bright Future*. This report adopts a "whole-of-system" approach, identifying multiple stakeholders and focusing on all aspects of grid-connected solar power: selection, deployment and commissioning of projects; bankability and the role of various financial channels; the development of a robust manufacturing base; and the creation of an enabling environment with regard to land, power evacuation, skills, and so forth.

I wish to congratulate the team comprising independent researchers from CEEW and NRDC, which has not only conducted in depth analysis of its own but also engaged with a wide set of stakeholders within and outside India. I am sure that the findings and recommendations of this report would be relevant not only for government agencies (at the national and state levels), but also for project developers, manufacturers, financiers, donor agencies, R&D and research institutions, and others keen on the success of the National Solar Mission.

Jamshyd N. Godrej
Co-Chairperson, Council on Energy, Environment and Water

Mumbai
April 2012

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LIST OF ABBREVIATIONS

ADB	Asian Development Bank
ARRA	American Recovery and Reinvestment Act
BEE	Bureau of Energy Efficiency
CCCL	Consolidated Construction Consortium Limited
CEEW	Council on Energy, Environment and Water
CERC	Central Electricity Regulatory Commission
CIF	Climate Investment Fund
CRISIL	Credit Rating Information Services of India Limited
CTF	Clean Technology Fund
CWET	Centre for Wind Energy Technology
DCR	Domestic Content Requirement
Discom	Distribution Company
EEG	Erneuerbare-Energien-Gesetz (Germany's "Renewable Energy Sources Act")
EPC	Engineering, Procurement, and Construction
EPIA	European Photovoltaic Industry Association
EU	European Union
EX-IM	Export-Import Bank of the United States
FIT	Feed-In Tariff
GIZ	Deutsche Gesellschaft für Internationale Zusammenarbeit
GW	Gigawatt
HBL	Hindu Business Line
ICICI	Industrial Credit and Investment Corporation of India
IREDA	Indian Renewable Energy Development Agency
JNNSM	Jawaharlal Nehru National Solar Mission
kWh	Kilowatt hour
LBNL	Lawrence Berkeley National Laboratory
LOI	Letter of Intent
MAHAGENCO	Maharashtra State Power Generation Company
MNRE	Ministry of New and Renewable Energy
MOEA	Ministry of Economic Affairs (Taiwan)
MOEF	Ministry of Environment and Forests
MOP	Ministry of Power
MW	Megawatt
NAPCC	National Action Plan on Climate Change
NASA	National Aeronautics and Space Administration
NCPRE	National Centre for Photovoltaic Research and Education
NRDC	Natural Resources Defense Council
NSM	National Solar Mission
NTPC	National Thermal Power Corporation
NVVN	NTPC Vidyut Vyapar Nigam
OPIC	Overseas Private Investment Corporation
OREDA	Odisha Renewable Energy Development Agency
PPA	Power Purchase Agreement
PSM	Payment Security Mechanism
PSS	Payment Security Scheme
PV	Photovoltaic
R&D	Research and Development
RE	Renewable Energy
REC	Renewable Energy Certificate
RPO	Renewable Purchase Obligation
SECI	Solar Energy Corporation of India
SEIA	Solar Energy Industries Association
SIPS	Special Incentive Package Scheme
SOLARCON	Solar Convention in India, Organized by SEMI
SPV	Special-Purpose Vehicle
TPVIA	Taiwan Photovoltaic Industry Association
WTO	World Trade Organization

I. EXECUTIVE SUMMARY

From tentative beginnings, India's solar energy market is picking up steam. From 17.8 megawatts (MW) in early 2010, cumulative installed capacity reached 506.9 MW at the end of March 2012.[1] The Jawaharlal Nehru National Solar Mission (NSM or Mission), launched in 2010, has catalyzed much of this growth. Even with 300 sunny days a year in most regions, creating a new solar energy market in India is no easy task.

Making headlines in late 2011, competitive bidding for the Mission's second batch of projects under Phase 1 drove prices for grid-connected solar energy as low as ₹7.49 ($0.15) per kilowatt-hour, approaching grid parity with fossil fuel-powered electricity. Phase 1 also attracted large conglomerates and new players into the solar market. "Bid euphoria," however, is wearing off, and serious doubts remain as to whether the Mission's Phase 1 projects will meet commissioning deadlines. Although several projects have been commissioned since January 2012, concerns about project delays are expected to overflow into future stages of the Mission. As the Mission heads into Phase 2, larger questions loom. It is unclear whether it is on course to achieve 20 gigawatts (GW) of installed solar capacity by 2022, and how the Ministry of New and Renewable Energy (MNRE, the nodal agency for the Mission) and other government agencies, as well as stakeholders—including developers, financial intermediaries, manufacturers and communities—can be more effective in scaling solar energy to power one of the world's fastest-growing economies.

The Solar Mission follows a phased approach that allows the government to modify guidelines and policies based on the experiences gained and lessons learned in earlier phases. This report adopts a "whole-of-system" approach, which identifies multiple stakeholders operating within the Mission and analyzes their successes and challenges. The report examines the commissioning of Phase 1 projects, efforts to increase bankability, the development of a manufacturing base, and the creation of an enabling environment. Addressing these challenges, the report presents findings and recommendations to scale grid-connected solar energy development. The report draws from extensive individual and group stakeholder discussions as well as research and analysis of national, state, and international programs.

PHASE 1 OF THE NATIONAL SOLAR MISSION: "BUILDING SOLAR INDIA"

During the Mission's first phase, more than 500 bidders competed for 63 projects allocated during two reverse auctions, driving prices to record lows. New solar energy investments in India increased to more than ₹12,000 crore ($2.5 billion) in 2011. Phase 1 activities have focused largely on achieving 1,000 MW of solar energy through an equal split between solar thermal and solar PV project technology. Although Indian industries have responded positively to the Solar Mission, it faces several hurdles in moving ahead. To scale solar energy, the central government—with coordinated action by states, developers, financial institutions, manufacturers, research institutes, and communities—needs to develop effective solutions for more credible project bids, enforceable Renewable Purchase Obligations (RPOs) and Renewable Energy Certificates (RECs), strong financial structures, increased domestic manufacturing, and reliable power evacuation and transmission. Moreover, off-grid solar energy, largely a missed opportunity so far, is ripe for investment.

OVERALL FINDINGS

1. The sophistication of solar energy stakeholders is increasing. However, a much greater degree of coordinated stakeholder action is needed to unleash the solar energy market's potential.
2. As an overarching policy framework, the National Solar Mission (NSM) aims to increase deployed capacity, enforce regulatory obligations for using renewable energy, create a manufacturing hub in India, and promote research and development (R&D) for new solar technologies. These objectives will be achieved in different time frames and therefore should be correctly prioritized by the central government.
3. Infrastructure, policy, and market conditions are shaping India's solar market differently from other solar markets. Unique attributes include the prevalence of ground-mounted solar parks, thin film PV technology used in more than half the projects, and low bid prices that make grid parity possible in the near future.
4. Overall, stakeholders viewed the reverse auction bidding process as transparent and successful in driving down prices. However, financial institutions, civil society groups, and some developers suggested that in order to draw serious players with an ability to ensure project completion, and attract financing, project selection criteria should be more rigorous. Moreover, for the Mission to remain credible, financial due diligence and continuous monitoring are needed to ensure that commissioned projects are operational at contracted capacity and generating solar power that is transmitted to the grid.
5. Indian bankers still perceive significant risks in the solar energy market and are largely hesitant to make substantial investments in solar technologies. International lenders, less risk-averse on the technology front, offer lower interest rates but remain skeptical about project completion. To bolster confidence among financiers, a range of funding channels, financial institutions, and other stakeholders must coordinate at program and project levels and provide ancillary support, such as R&D and skill development, to help the solar market mature.
6. State policies have contributed to boosting solar projects in the past two years, especially in Gujarat and Rajasthan. For Phase 2, the central government needs to increase collaboration with states to facilitate RPO and REC compliance, project bidding, financing, power evacuation, transmission, and land acquisition.
7. While the domestic content requirement (DCR) has garnered international attention and raised concerns among some foreign stakeholders, most developers do not identify it as a major barrier to project development. The case for a robust domestic manufacturing base rests on multiple objectives: energy security, technology development, energy access, ensuring product standards, attracting foreign investment, and creating jobs. Even so, many manufacturers expressed the view that the DCR, as currently structured, is not sufficiently stimulating local manufacturing. Manufacturers face other systemic limitations, such as poor infrastructure, lack of raw materials, an undeveloped supply chain, and lack of financing.
8. Many developers have faced difficulties in obtaining clearances to convert land use for solar project development and encountered claims by other parties to government-allocated land. In terms of infrastructure, some developers have experienced difficulties with power evacuation and transmission lines to substations. Limited availability of skilled labor also remains a barrier to wide-scale project development.
9. To protect local interests and the environment, developers and government agencies need to increase community involvement in the decision-making process, from project planning to operations.
10. All stakeholders agree that while Phase 1 focuses on grid-connected projects, off-grid solar energy provides an even larger opportunity. They state further that stakeholders should work collectively to develop both public and private strategies for large-scale deployment of off-grid projects.

BANKABILITY: FINANCING SOLAR ENERGY PROJECTS

In 2011, investments in India's renewable energy markets rose to approximately ₹51,000 crore ($10.3 billion),[2] with more than one-third of the investments directed to solar projects. Investments are expected to double for Phase 2. Yet the greatest challenge for solar energy is project financing. Even for smaller Phase 1 projects, developers struggled to raise capital from multiple domestic, international, and self-financing sources. While there has been some improvement, most domestic banks still perceive significant risks in solar investments. International and bilateral lending institutions that supported several Phase 1 projects remain interested in supporting additional projects but want more rigorous project selection requirements, such as balance sheets and vetted collateral. Well-structured RPOs, RECs, and innovative funding mechanisms are opportunities for increasing investments in solar energy. In short, with major information gaps and potential market failures, financial markets will not automatically warm up to the solar market without strategic interventions to create a financing ecosystem.

Key Findings for Bankability

1. India's high interest rates impede project development, especially as the costs of solar plants are largely in up-front capital. Overseas financing is more attractive, both for lower interest rates and for longer-term debt, which match the longer payback period of solar loans.

2. Banks have a low comfort level with solar investments because of the lack of information available, and need more data and statistics on project development, deployment, and performance. They also need irradiance measurements from local settings, which are currently not recorded.
3. Financial institutions perceive solar energy in India as a riskier investment because it is a fledgling industry without a proven track record in meeting commissioning deadlines, performance benchmarks, and delivering power.
4. RECs represent an opportunity to support the solar market, but regulators need to strengthen the mechanisms for trading and enforcement since uncertainty about enforcement diminishes investor confidence.
5. Capacity building and networking among banks and other financial intermediaries are needed to increase information sharing and awareness within the financial community. The Ministry of New and Renewable Energy (MNRE) has initiated activities toward awareness building and information dissemination, but much more can be done.

Key Recommendations for Bankability

1. Regulators should diligently enforce RPO mandates and the REC market. National and state agencies should work together closely to ensure effective RPO and REC systems.
2. With the Reserve Bank of India and the Ministry of Finance, MNRE should encourage priority sector lending for large-scale solar projects to help reduce lending rates to as low as 10 percent and to provide higher employment potential for downstream solar activities.
3. To provide longer-term debt, the government should enhance funding mechanisms, including the proposed Infrastructure Debt Funds. To further reassure financiers, MNRE should share information on the payment security mechanism (PSM) and clarify how the PSM has been calculated to effectively cover potential default on payment.
4. Government agencies and private groups should provide solar resource and project deployment data as soon as they become available. MNRE and the Solar Energy Corporation of India (SECI) should work with developers to establish monitoring and reporting processes that can be implemented before Phase 2. SECI should become a central clearinghouse for all information dissemination relating to the solar ecosystem. A sharing platform for improved irradiance data should be created to disseminate information as it is generated.
5. The Solar Advisory Panel and leading financial institutions should create a network of solar finance leaders to develop bank products that support solar energy. Such a network could work together to syndicate loans, share information, and conduct workshops where bankers, developers, manufacturers, and entities in engineering, procurement, and construction (EPC) can come together to exchange knowledge and experiences about solar investments.

MANUFACTURING: SUPPORTING A DOMESTIC INDUSTRY

Solar cell and module manufacturing offers India a long-term opportunity to become a major manufacturing player, accelerate grid-parity, and build a sustainable solar industry. The Mission's Phase 1 domestic content requirement mandated local manufacturing of crystalline PV modules for Batch I projects, and both cells and modules for Batch II projects, while exempting thin film PV. While most local stakeholders strongly favor domestic manufacturing policies, at this stage it seems that the DCR has been only marginally effective in creating a vibrant domestic manufacturing base.

Key Findings for Manufacturing

1. Phase 1's domestic content requirement has contributed to shifting the market toward thin film PV projects due to their exemption from the DCR. Fifty-percent of Batch I projects use thin film and crystalline cells, a larger proportion than in the global PV market. Batch II projects use even more thin film technology, probably because Batch II requirements for domestic crystalline cell manufacturing have made lower-priced, imported thin film, often coupled with low-cost international financing, more attractive to developers.
2. The Phase 1 domestic content requirement as currently structured has not effectively created the market conditions for local solar PV manufacturing envisioned by the NSM. The DCR has not created a level playing field. Instead it has contributed to a strong thin film bias and has possibly been a detriment to Indian crystalline-based manufacturing.
3. The Indian solar cell manufacturing system requires systemic improvements in infrastructure, domestic low-cost financing, and raw materials.
4. More than half the jobs in the solar value chain and value creation are not in solar manufacturing, nor specifically in cell and module manufacturing. Severe environmental costs linked to unregulated solar manufacturing also exist.
5. A modified DCR could have a positive influence on domestic manufacturing if it is technology-neutral and not overly restrictive.

Key Recommendations for Manufacturing

1. The central government, with stakeholder input, should explore whether incentivizing policies with a broader scope than solely cell and module manufacturing would capture more value and create more solar jobs within the Indian context.
2. MNRE should tailor the DCR to be technology-neutral and market-enabling. MNRE could explore two options: (a) a DCR requiring that all PV modules be manufactured in India, uniformly enforced across all PV technologies, or (b) a DCR specifying that a certain percentage of solar PV components be manufactured in India.
3. To avoid being restrictive and to lessen the potential for international controversy or trade disputes, MNRE could consider incentives other than a DCR, such as a preferential tariff, to promote domestic manufacturing.
4. Manufacturers should strengthen existing networks, such as SEMI, to explore ways to ease barriers to manufacturing in India. The manufacturing networks could develop policy proposals to address natural resource, finance, and trade limitations.
5. MNRE should work with the Ministry of Environment and Forests to strengthen environmental safeguards to ensure that manufacturing can continue to grow rapidly while protecting community health and the environment.

ENABLING ENVIRONMENT: FACILITATING LAND ACQUISITION, PERMITTING, AND POWER EVACUATION

One of Phase 1's immediate goals is to create an "enabling environment" for solar technology penetration in India. In addition to the broader areas of bankability and manufacturing, our discussions with stakeholders identified four main causes for delays in project implementation: land acquisition issues, concerns with power evacuation, the lack of effective community involvement, and the lack of a comprehensive Solar Mission implementation plan.

Key Findings for Enabling Environment

1. Land acquisition issues, including siting, clearances, and grid proximity, are delaying projects. Currently, land costs represent a small share of total project costs and are not the most significant barrier to land acquisition. While in early stages, solar parks have proved to be effective in facilitating project development and reducing delays.
2. Several developers and financiers have identified power evacuation and access to the grid as issues of concern, and in their absence, it has been difficult to secure financing for projects.
3. Developers are confused about which entity or agency is responsible for last-mile infrastructure, resulting in project delays.
4. Actively involving communities in every stage, from planning to operation, will strengthen solar energy projects. Project developers already recognize that there are co-benefits that can be shared with local communities and that problems can arise if local communities are not engaged throughout the process.
5. To enable industry progress, developers, banks, and other stakeholders have identified the need for a long-term implementation plan that focuses on the entire supply chain, investment in research and development, labor force training, and the provision of sufficient and customized financial incentives.

Key Recommendations for Enabling Environment

1. The central government should closely and systematically coordinate with state governments on project allotment, land acquisition, and project development, particularly for the larger Phase 2 projects. Specifically, MNRE should work with states to develop effective land allocation strategies for solar projects, including strategies to facilitate siting and planning requirements.
2. MNRE should also collaborate closely with the Ministry of Power to plan for transmission infrastructure upgrades within a long-term power planning framework focused on scaling renewable energy.
3. Before bidding for Phase 2 projects begins, MNRE and developers should work together to resolve whether last-mile infrastructure costs should be included in project estimates.
4. To strengthen solar projects, developers should integrate local communities at the planning stage through regular community meetings and engagement.
5. The solar industry should create a network of solar energy groups focused on resolving common industry concerns, interacting with government agencies, developing solutions for the entire solar supply chain, investing in research and development, and increasing the solar energy workforce.

LOOKING AHEAD: THREE POLICY PRIORITIES

While the Indian government and solar energy stakeholders have made significant progress, much more needs to be done. Implementing three key policy priorities this year would enable strong growth under the Solar Mission:

Benchmarks, Transparency, and Monitoring: There is an urgent need to increase the level of information available on the Mission's progress. The government should enforce periodic updates on each project's progress, without which its project selection process and due diligence will be called into question. The government should adopt a common definition of "commissioning" as well as common benchmarks for commissioning projects under the state and national

Missions. Moreover, for financiers to become more familiar with technologies, and for component standards to be closely monitored, project technology choices need to be transparent. Finally, irradiance data must be made publicly available to increase confidence and investment in the solar market.

Strategic Financing: Central and state government agencies, with MNRE's leadership, should develop a strategy to optimize the roles of different financial institutions. As the market matures, various institutions should leverage their expertise to grow India's solar market. For example, certain groups should focus on providing project financing, while others should focus on disseminating information to the market, and others should focus on R&D and skill development. Only when a comprehensive financing strategy is in place will different financial interventions (e.g., priority sector lending, development of the REC market, and the role of infrastructure debt funds) succeed in scaling solar energy investments.

Technology-Neutral Manufacturing: To make domestic manufacturing policies technology-neutral and market-enabling, MNRE could explore the following options: (a) a DCR requiring that all PV modules be manufactured in India, uniformly enforced across all PV technologies; or (b) a DCR specifying that a certain percentage of the solar PV components be manufactured in India; or (c) a preferential incentive to promote domestic manufacturing instead of a DCR to avoid being restrictive and to lessen international controversy.

The NSM has the potential to transform India's energy sector and help power its rapid economic growth while building a sustainable future. India needs continued government and private sector support, increased investment in manufacturing, and increased technology sharing to unleash this potential in the Mission's next phase. This report's recommendations are submitted with a view toward promoting a comprehensive and strategic approach to building a robust grid-connected solar industry in India.

II. INTRODUCTION

India has entered a defining phase in its development. The country needs energy to fuel economic growth. However, with fossil fuels accounting for 70 percent of its primary energy supply,[3] India is constrained by the limits imposed by dependence on imported fossil fuels and the imperative to mitigate greenhouse gas emissions. An accessible and affordable clean energy source is necessary to power India's rapidly growing economy and promote low-carbon energy development.

As the country emerges as a global economic powerhouse, with a growing population expected to reach 1.47 billion by 2030, its energy consumption will increase substantially.[4] Unfortunately, current energy supply cannot keep up with growing demand. Rolling power cuts from energy deficits already reach 9 percent in the electricity sector.[5] This current lack of capacity excludes the 400 million Indians who have no access to modern electricity at all. With rapidly urbanizing cities demanding more power, renewable energy—including solar—is critical to provide electricity while reducing dependence on imported fuels and combating climate change.

NATIONAL ACTION PLAN ON CLIMATE CHANGE

- National Solar Mission
- National Mission for Enhanced Energy Efficiency
- National Mission on Sustainable Habitat
- National Water Mission
- National Mission for Sustaining the Himalayan Ecosystem
- National Mission for a "Green India"
- National Mission for Sustainable Agriculture
- National Mission on Strategic Knowledge for Climate Change

In 2011, the Indian government announced a new mission to improve coal plant technologies.

INDIA'S OPPORTUNITY FOR SOLAR ENERGY

With nearly 300 sunny days and high solar radiation in most regions, India has abundant solar energy potential.[6] As the world's third-largest energy consumer, and with a surging middle class, India also provides a unique opportunity for a thriving solar market.[7] The precipitous drop in solar photovoltaic (PV) panel prices has coincided with the rising cost of grid power, quickly making solar cost-effective and shortening the projected timeline to achieve grid parity.[8]

With energy consumption projected to escalate and domestic energy sources like coal becoming scarcer, India needs alternative sources of energy to power its growing needs. As a local, abundant, and inexhaustible resource, solar energy provides several long-term benefits to address the urgent problems India faces now. With its potential to reduce reliance on imported and unreliable fossil fuels, solar power is an important part of India's portfolio approach to energy security.

In addition to its diversification role in India's energy mix, solar energy clearly functions as part of India's response to climate change. Solar energy can lower the costs of mitigating climate change while helping India achieve its voluntary target of reducing carbon emission intensity from 2005 levels by 20 to 25 percent by 2020. Solar power has the potential to eliminate 95 million tons of CO_2 emissions annually by 2022.[9] As a clean and renewable energy source, solar technology has other local environmental benefits, particularly reducing smog and air pollution. India's ground-mounted projects have limited negative consequences, such as being very land-intensive.[10]

CREATING A NEW INDUSTRY: JAWAHARLAL NEHRU NATIONAL SOLAR MISSION

Despite its potential, India's solar power capacity was almost nonexistent until recently. Creating a new industry, especially in the energy and electricity sector, is no easy task. Several questions arise: Should the focus be on grid-connected or off-grid power? If the former, do transmission lines exist in areas with the maximum potential for generating solar power? And what policies are needed to encourage deployment? Should these policies prioritize extending energy access or reducing electricity costs? How soon could a domestic manufacturing

industry develop to meet demands? Should India rely on domestically manufactured solar panels or remain open to imports? And how would India ensure that imported panels had consistent and reliable quality? How would the country balance deployment of existing technologies and research and development (R&D) of new ones? Under what conditions would financial institutions invest in a nascent industry? What interventions could reduce the cost of capital, and how would the industry access Indian and foreign sources of finance? How could the industry acquire land and access to other infrastructure to execute projects on time? Finally, how can all this happen in a manner that is transparent (to avoid corruption), flexible (to incorporate cumulative experience), and predictable (offering policy consistency over a sufficient period to encourage long-term investments)?

Set against these wide-ranging challenges, the MNRE launched the Mission in January 2010. Announced by Prime Minister Manmohan Singh in June 2008, it was one of eight (now nine[11]) national missions outlined in the National Action Plan on Climate Change (NAPCC) (see "National Action Plan on Climate Change," above). One of the NAPCC's aims is to address climate mitigation and adaptation, with the vision to make India's economic development energy-efficient.[12] In accordance with the NAPCC, the NSM set bold targets emphasizing grid-connected applications, seeking to install 20,000 MW of grid-connected solar power and 2,000 MW of off-grid solar power by 2022. Qualifying projects are selected through a reverse auction procurement mechanism and are ostensibly technology-neutral, employing either solar PV or solar thermal technology.

The NSM Mission Document, released by MNRE in November 2009, sets out the Mission's varied targets and objectives and provides guidelines and policy tools to achieve these goals.[13] The NSM's grid-connected solar energy targets offer clear benchmarks against which to measure the Mission's progress. The NSM targets have been planned in three phases (see Table 1). In addition to meeting these concrete targets, the NSM's guidelines also set out several diverse objectives with different timetables (or, in some cases, no clear timetable) to achieve them.

DIVERSE OBJECTIVES

The National Solar Mission aims to achieve a wide range of ambitious objectives, with the overall stated goal of "establish[ing] India as a global leader in solar energy, by creating the policy conditions for its diffusion across the country as quickly as possible."[14] The Mission Document's objectives consist of both specific goals to be accomplished within the phased timeline, and broader goals without a definite deadline.

Phase 1 focuses on setting up an environment to enable solar technology penetration at a centralized and decentralized level.[15] Phase 1's guidelines explicitly aim to facilitate quick implementation of the NSM, while ensuring serious participation by—and enhanced confidence in—the selected project developers. Promoting manufacturing in India's solar sector is another Phase 1 goal.

Phase 2 contemplates an aggressive capacity ramp-up to facilitate competitive solar energy penetration in India. The guidelines envision scaling up through enforcement of a mandatory renewable purchase obligation (RPO) for utilities, backed by a preferential tariff.

Phase 3, the final phase, aims to meet or exceed the end target of 20,000 MW of grid-connected solar by 2022. Rapid scaling-up of installation during Phase 3 is anticipated through the availability of international finance and technology. The NSM seeks to achieve grid parity by 2022 and parity with coal-based thermal power by 2030.

The Mission Document anticipates that utility-scale solar power in India will be driven by the RPOs mandated for power utilities, with a specific solar energy component. Generally, the NSM aims to craft a policy and regulatory environment that provides a predictable incentive structure, enabling rapid and significant capital investment in solar energy applications while encouraging technical innovation and reducing costs. The Mission hopes to accomplish all of these ambitious objectives through its guidelines and incentives.

The NSM also aims to transform India into a solar energy hub, making it a global leader in low-cost, high-quality solar manufacturing across the value chain. The Mission Document envisions creating favorable solar manufacturing

TABLE 1: National Solar Mission Targets 2010 to 2022

SOLAR TECHNOLOGY	PHASE 1 (2010 to 2013)	PHASE 2 (2013 to 2017)	PHASE 3 (2017 to 2022)
Grid-connected/ rooftop	1,000 MW - 2,000 MW	4,000 MW - 10,000 MW	20,000 MW
Off-grid solar applications	200 MW	1,000 MW	2,000 MW
Solar hot water collectors	7 million sq. meters	15 million sq. meters	20 million sq. meters
Rural solar lanterns/ lighting	N/A	N/A	20 million systems

Source: Mission Document

conditions, particularly for solar thermal for indigenous production and market leadership. The guidelines target a 4 GW to 5 GW equivalent of installed production capacity by 2020, including dedicated manufacturing capacities for polysilicon material to make solar cells amounting to about 2 GW of generation capacity annually. The key to accomplishing this goal, according to the Mission Document, is promoting PV manufacturing plants (including facilities for the domestic manufacture of silicon material), thereby reducing dependence on imports of raw materials.

The Mission also highlights a major R&D initiative to promote technology development and cost reduction. The top priorities of this program include improving efficiencies in existing materials and applications, reducing costs of solar systems, and establishing new applications that improve integration. Rather than locking into specific solar technologies, the Mission states that it is neutral, allowing market conditions to determine technology.[16]

SOWING THE SEEDS TO GROW SOLAR?

The NSM's role is perhaps best understood as sowing the seeds of a new industry and nurturing the early stages of its growth. Its many objectives operate according to different timelines and a dynamic set of guidelines. Some objectives (such as establishing the first 1,000 MW of capacity) may be met more quickly than others (developing a manufacturing base or broadening financial sector involvement). Some objectives may be open-ended bets on the future, like technology development, where the role of the NSM (and MNRE) might be fairly small compared with other parts of government and industry.

The success of the Mission, measured against multiple objectives, is also contingent on coordination among existing and new institutions. The NSM is overseen and implemented by MNRE. The NTPC Vidyut Vyapar Nigam (NVVN)[17] enters into 25-year power purchase agreements (PPAs) to procure power from project developers and supply an allocated amount of MW capacity to the utilities. MNRE and NVVN also manage a payment guarantee fund to insure NVVN against losses, should the power remain unsold or the buyer default on payments.[18] The Indian Renewable Energy Development Agency (IREDA), a public limited government company that operates as MNRE's financial arm, finances solar PV projects. Most recently, the Solar Energy Corporation of India (SECI) was created to serve as the executing arm of the NSM.

Has the NSM performed according to plan? Are the numerous objectives and multiple timelines internally consistent, or do they place an undue burden on a single Mission? In fact, can so many objectives (installing capacity, reducing costs, creating a manufacturing hub, encouraging R&D, balancing grid and off-grid projects) be achieved through a single policy framework? This report has been prepared to address these questions.

Focusing on grid-connected solar power, the report adopts a comprehensive approach to identify all the moving parts and multiple actors and institutions operating within the Mission.[19] It analyzes how each component of the solar ecosystem has performed and what conditions enhance or impede chances of success. For each aspect—setting up projects, increasing their bankability, developing a manufacturing base, and creating an enabling environment—the report identifies issues facing key stakeholders, analyzes what role the NSM has played in filling existing gaps, and offers recommendations for improving implementation in subsequent phases. In doing so, we draw upon examples from other state missions within India as well as solar programs in other countries. The success of India's solar endeavor not only matters for its energy security and environmental imperatives, but also could offer lessons for other countries seeking to scale up access to clean, affordable, and sustainable energy to millions of people worldwide.

III. STAKEHOLDERS: NEED FOR A SOLAR ECOSYSTEM

Realizing the Mission's objectives for a vibrant solar sector depends on a robust solar ecosystem in India. A solar ecosystem refers to the entire environment, conditions, and stakeholders through which solar energy is created, purchased, and used. A successful solar ecosystem is dependent on the collective effectiveness and coordination among these stakeholders and can be arranged into the following three levels: the strategic policy level, the project level, and the supporting environment (see Figure 1).

FIGURE 1: A successful solar ecosystem depends on the effectiveness of various individual enablers and stakeholders and coordination among these

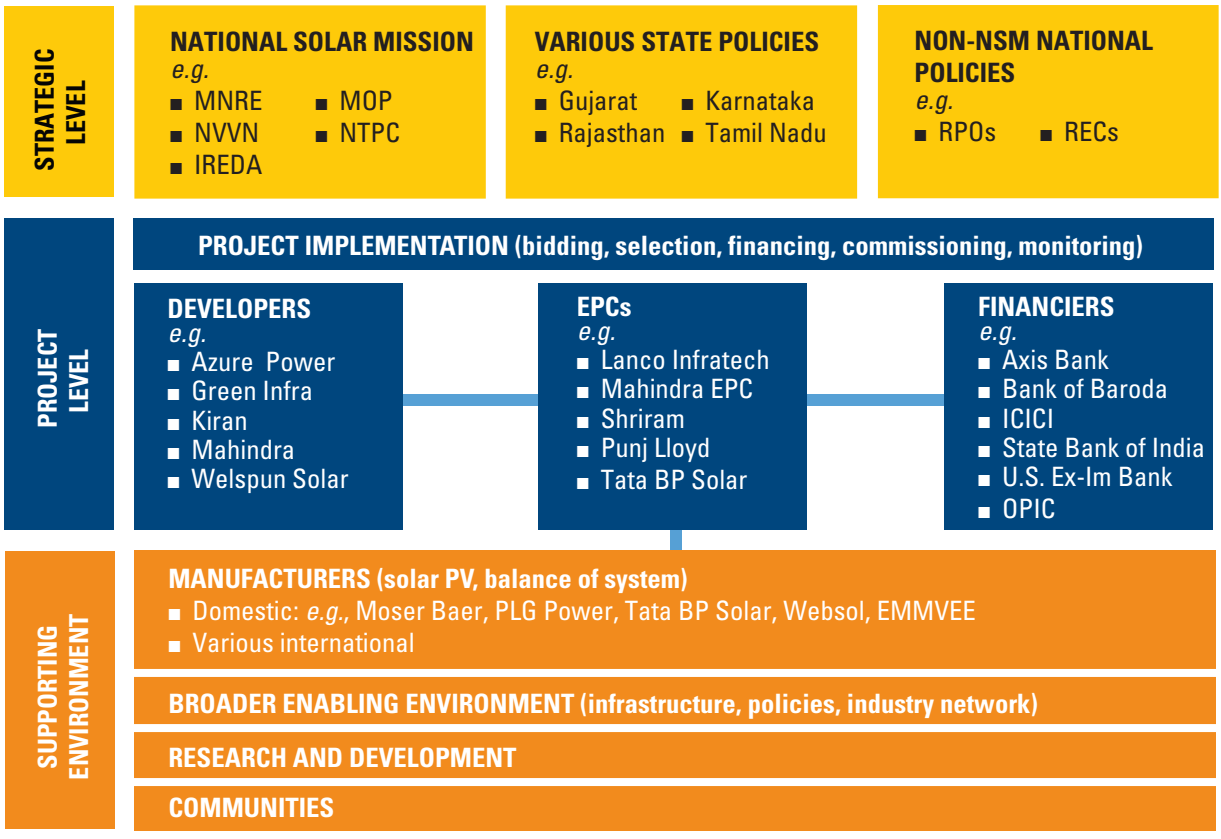


TABLE 2: National Solar Mission Solar Project Process

PROCESS STEP	TIMING	DESCRIPTION
Solicitation	Day 1	MNRE and NVVN request bids from project developers.
Bidding	Day 1 + 30 days	Project developer submits bid, which undergoes initial screening to ensure it meets technical criteria.
Selection	Day 1 + 120 days	MNRE and NVVN choose technically qualified bids through reverse auction mechanism based on lowest-priced bids, selecting winning projects until the available MW capacity is allotted.
Entering LOI	Day 1 + 135 days	MNRE and NVVN issue letter of intent (LOI) within 15 days of selection.
Signing PPA	LOI + 30 days	NVVN signs power purchase agreement (PPA) with project developer.
Financing	PPA + 180 days	Project developer secures project financing, typically with financial institution, by financial closure deadline.
Commissioning*	PPA + 365 days	Project developer must produce solar power by commissioning deadline, paying penalty fees to NVVN for delays up to 6 months, at which time PPA is terminated.
Monitoring	Ongoing	NVVN monitors project to ensure that power commitments are met.

* The commissioning responsibility may be transferred to EPC contractors, depending on the terms of the bilateral contracts.

STRATEGIC LEVEL

Without a policy framework that is transparent, long-term, and credible, it is unlikely that a nascent industry will attract the level of investment commensurate with its scale of ambition. This is the most important role for a national-level mission: bringing together different aspects and various actors in the solar ecosystem under a single umbrella. Thus, the following top-down policies and strategies are being implemented to create and shape the demand for solar power in India and to promote the growth of the nascent Indian solar industry:

- **National Solar Mission** (see Table 2);[20]
- **State policies,** which could either complement the Mission or offer alternative policy designs for project developers to choose from;[21] and
- **Non-NSM national policies,** particularly Renewable Purchase Obligations (RPOs) and Renewable Energy Certificates (RECs).[22]

PROJECT LEVEL

The overarching strategies translate into particular policy tools at an individual project level. These policy tools govern the project implementation process, which requires the following key project stakeholders to work in unison:

- **Project developers,** who bid for projects under the NSM and, if successful, are primarily responsible for commissioning projects on time to supply the committed amount of solar-generated electricity into the grid;
- **Engineering, procurement, and construction (EPC) contractors,** implement projects for developers and have expertise building projects and understanding the "on-the-ground" challenges affecting project completion; and
- **Financiers,** including Indian commercial banks, Indian nonbanking financial institutions, and international funding channels (e.g., government-promoted funds, multilateral development banks, and public-private funds).[23] These entities provide different types of financial capital (e.g., debt, loan guarantees, and risk insurance) to commission the solar plant (often in addition to a developer's equity contribution).[24]

SUPPORTING ENVIRONMENT

The supporting environment encompasses all other players and policies that help facilitate the successful implementation of the solar project. This level includes: communities, without whose active engagement and involvement the projects risk losing legitimacy or facing challenges during the implementation and operation phases; accommodating infrastructure, such as available land and access to the grid (including operational substations); and the following key supporting stakeholders and components:

- **Manufacturers,** which provide solar equipment to developers and EPC contractors, and whose solar components or raw materials are either supplied domestically or imported;[25]
- **Research and Development programs**, which extend across the entire solar value chain and cover both product and process innovations, from new technologies to manufacture, and from installation to power plant operation;[26] and
- **Broader enabling government policies,** which facilitate the creation of a supportive solar environment on both national and state levels.[27]

All of these policies and key stakeholders enable India's solar market to get off the ground. In subsequent sections, this report discusses how these policies and stakeholders have fared during Phase 1 of the NSM and considers possible improvements to a suite of policies to facilitate a smoother roll-out and scaling-up of solar projects.

IV. PHASE 1 OF THE NATIONAL SOLAR MISSION: "BUILDING SOLAR INDIA"

> *"The immediate aim of the Mission is to focus on setting up an enabling environment for solar technology penetration in the country both at a centralized and decentralized level."*
>
> — JNNSM Mission Document

As the first stage of the Solar Mission, Phase 1 is vital to creating a solid foundation for India's solar energy market. As the Mission Document states, "the ambitious target for 2022 of 20,000 MW or more will be dependent on the 'learning' of the first two phases, which, if successful, could lead to conditions of grid-competitive solar power."[28] MNRE explicitly built in flexibility so that the Mission's approach would evolve in response to lessons learned during the first phase, contributing to the overall success of the Misson.

Phase 1 aims to ramp up grid-connected solar energy to 1,100 MW by 2013 with 500 MW of PV, 500 MW of concentrated solar thermal and 100 MW of rooftop PV.[29] When Phase 1 began, many viewed the Mission's goals as overly ambitious, especially since India had little solar PV and no solar thermal projects in 2010.[30] Two-thirds of the way into Phase 1, India's grid-connected solar energy market has grown tremendously, with an increased number of developers, lower prices, and interested financial institutions. India's solar energy market grew from 17.8 MW in early 2010 to 506.9 MW cumulative installed capacity as of March 26, 2012.[31] Of this capacity, 203.4 MW was commissioned under the National Solar Mission and other central government schemes. Another 303.5 MW was deployed under initiatives of various states. Despite this early success, as Phase 1 enters its final year, the Mission is experiencing the pains and stumbling blocks of fast-paced growth. As Phase 1 concludes, effective government policies, backed by sufficient resources, are essential to creating a robust solar energy market. Looking ahead, Phase 1 offers important lessons for Phase 2.

OFF-GRID SOLAR POWER IN RURAL INDIA

Through MNRE's ongoing remote village electrification program, the NSM aims to provide solar lighting systems to 10,000 villages and hamlets through a 90 percent subsidy. Stand-alone rural solar power plants will also be established. The NSM also retains flexibility to consider a 30% capital subsidy to promote solar energy's innovative applications, like powering school computers and milk-chilling plants.

As of 2010, 40 percent of India's population lacked grid-connected electricity. Now, remote rural villages have an opportunity to receive economical off-grid solar energy where grid penetration is not feasible or cost-effective.

Off-grid solar energy's advantages include:

- Improved access to energy sources
- Affordability
- Adaptability
- Ease of installation and maintenance

Off-grid solar power is currently a missed opportunity and the government, including MNRE, needs to do more to promote off-grid applications in rural India.

PHASE 1 PROJECT ANALYSIS AND DISCUSSION

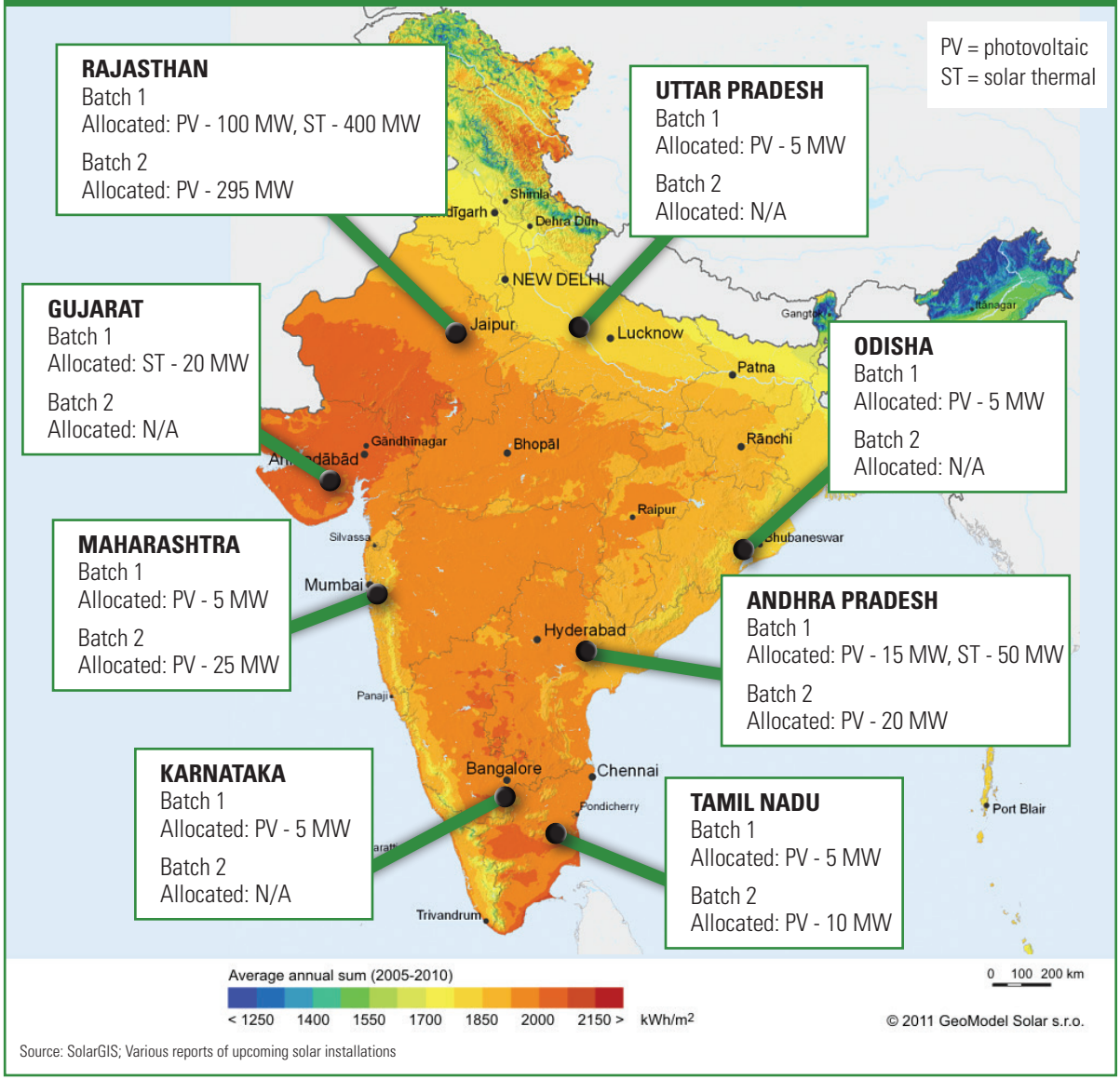
Phase 1 of the Mission has focused largely on grid-connected projects thus far. To achieve 500 MW of PV and 500 MW of concentrated solar thermal, the central government conducted two batches of reverse auctions. These bidding processes offer feed-in tariffs and long-term PPAs to the selected least-cost developers. The feed-in tariffs to developers are complemented by support to power utilities through the bundling of solar power with conventionally produced electricity, reducing the average per-unit cost of solar power (see Figure 3).

TABLE 3: National Solar Mission Phase 1

BATCH SPECIFICATIONS	ALLOCATIONS UNDER BATCH I (2010 to 2011)	ALLOCATIONS UNDER BATCH II (2011 to 2012)
Total capacity of grid-connected solar projects selected	150 MW (PV)[a] 470 MW (solar thermal) 84 MW (migrated)	350 MW (PV)
Maximum size allotment	5 MW per project & bidder (PV) 100 MW per project & bidder (solar thermal)	20 MW per project (PV) 50 MW per bidder (PV)

[a] Two of the 30 PV projects originally awarded under Batch I were canceled due to developers' inability to meet NVVN criteria.

FIGURE 2: Rajasthan and Gujarat, which are endowed with the highest irradiation, led Phase 1 installations



Source: SolarGIS; Various reports of upcoming solar installations

1. Reverse Auctions: Leveling the Playing Field

For both batches of Phase 1, the Indian government used the reverse auction as a price discovery mechanism. Reverse auctions have two main benefits. They allow government procurers to select projects based on lowest cost (thereby keeping the burden on fiscal resources and taxpayers low), and they ensure that a price-based selection process will be transparent and fair. The government made a substantial effort to ensure transparency in Phase 1's project allocations, since any accusation of corruption in the bidding and project selection process could jeopardize the entire program while still in its infancy. Project developers then bid on discounted tariffs set by the Central Electricity Regulatory Commission (CERC). A 5 MW parcel-size requirement for Batch I and 20 MW maximum parcel-size requirement for Batch II opened the market for a broad range of companies to enter the sector—as long as they met the criteria set out in the guidelines (see "Batch I Selected Project Developers," below). The government kept project sizes small to encourage more entities to take advantage of the opportunity rather than lock in a few firms as dominant players at this early stage of the industry. Some large players participated to diversify their portfolios by investing in solar energy, while some smaller entrepreneurs made successful bids to capitalize on the emerging solar market.

While largely praised, the reverse auction has also been criticized. Some conservative stakeholders have disparaged the reverse auction as driving prices so low that some projects are "half-baked" in terms of financing and due diligence, resulting in financially unviable projects. The reverse auction process has also been criticized for not adequately vetting bidders, since the eligibility criteria simply required that bidders have a minimum net worth of ₹150 million (about $3 million).[32] The resulting selection of some inexperienced, small developers quoting very aggressive prices has caused fears that many projects may not be commissioned (although, in the first quarter of 2012, several projects have come on-stream after delays). Conversely, inadequate vetting and monitoring have also led to accusations that large companies such as Lanco Infratech have exploited the guidelines and may corner a significant market share of NSM projects.[33]

BATCH I SELECTED PROJECT DEVELOPERS

Large and small developers emerged during the bidding process, including the following selected Batch I PV awardees: Azure Power, Rithwik Projects, Saisudhir Energy, Welspun Solar, Coastal Projects Limited, Karnataka Power Corporation, Camelot Enterprises, Alex Solar Private, Alex Spectrum Radiation, Bhaskar Green Power, DDE Renewable Energy, Electromech Maritech, Finehope Allied Energy, Greentech Power, Indian Oil Corporation, Khaya Solar Projects, Newton Solar, Maharashtra Seamless Limited, Mahindra Solar One, Northwest Energy, Oswal Woollen Mills, Punj Lloyd, Saidham Overseas Private Limited, Viraj Renewables Energy, SunEdison, Vasavi Solar Power, Amrit Energy, CCCL Infrastructures, Electrical Manufacturing Company, and Precision Technik.

Companies awarded Batch I solar thermal projects in Phase 1 included: Megha Engineering, Aurum Renewable Energy, Ispat Alloys, Godawari Power & Ispat, KVK Energy, Rajasthan Sun Technique Energy, and Lanco Infratech.



5 MW grid-connected solar photovoltaic plant jointly developed by SunEdison and Azure Power, installed in Dhama village, Patdi Taluk, Surendranagar, Gujarat.

CREDIT: SUNEDISON

2. EPC Contractors Emerging as Central Players

In Phase 1, the EPC contractors have risen as a central force in the emerging solar energy market. Project developers with limited experience in the solar market have relied heavily on their EPC contractors to support their projects with potentially unsustainable bid prices. The role of an EPC can cut both ways. On one hand, EPCs have experience executing projects, and the more experience they gain, the further marginal costs of installing additional projects could be reduced. But too much reliance on an EPC can also blur the distinction between the project developer, who holds ultimate responsibility for producing solar electricity, and the contractor. Projects should ultimately be selected after due diligence on both developers and associated EPC contractors; their separate capabilities and responsibilities have to be judged on their own merits, and they must be held accountable on those terms. The bidding process for Phase 1 has delivered on some requirements for transparency, but this is an area that needs attention in coming phases.

3. Market Consolidation

Phase 1 is also a mechanism to test and evaluate the performance of project developers, giving experienced entities a chance to prove their track record and allowing many domestic and foreign developers to enter the Indian solar market. One Indian developer predicted that although the solar energy market had immense growth potential, it

was likely to consolidate 8 to 10 primary developers. The significantly lower number of companies participating in Batch II bidding, as compared to Batch I, is an early sign of such consolidation.[34]

The experience of other solar markets, like California, suggests that consolidation is a sign of a maturing industry. In India, companies such as Welspun, Azure Power, Mahindra Solar, and Lanco Infratech are starting to dominate the solar market. While the Batch II 50-MW limit per project developer remains a low threshold for a growing market, consolidation of companies is likely to continue as the market matures.

4. Interplay Between the NSM Phase 1 and State Projects

Clearly, it is not just the National Solar Mission that is driving the solar industry; state-level programs are having an impact as well. As Phase 1 bidding was under way, several states launched their own solar energy programs. For example, Welspun began new projects under Gujarat's policy and also competed for Karnataka's allotments. Similarly, Azure Power has a 2 MW solar power plant under operation in Punjab, and MAHAGENCO is working to commission a 150 MW plant in Maharashtra.[35] Valuable experience and scale from multiple projects are giving these bidders the confidence to bid low and yet be profitable. The central government coordinated with several states during Phase 1, but increased coordination will be needed given the scale of Phase 2 projects.

PHASE 1'S TIERED APPROACH

The NSM's phased timeline, divided further into batches of selected projects, manages the pace of the Mission in a sustainable way while accomplishing interim targets. Both batches of Phase 1 were considered initial successes for the Mission, but it is too early to determine whether individual selected projects can claim success.

1. Batch I Projects: Boosting Solar Energy

During the reverse auction process for Batch I, 36 projects were selected, with nearly 400 developers bidding in late 2010.[36] A total of 140 MW were allocated to 28 PV projects and nearly 470 MW to seven solar thermal projects.[37] The Indian government also migrated existing solar projects to count toward the Solar Mission, at a premium tariff of ₹17.91/kWh ($0.45/kWh), providing an additional 84 MW of capacity. The Indian government started the reverse auction price at ₹17.91/kWh ($0.45/kWh). The lowest bid price was ₹12/kWh ($0.32/kWh). Since two PV projects failed to meet NVVN requirements, they were withdrawn from the process. Nineteen of the Batch I PV projects are located in Rajasthan; the others are in Gujarat, Maharashtra, Karnataka, Tamil Nadu, Andhra Pradesh, Odisha, and Uttar Pradesh.

Although stakeholders complimented the reverse auction for its transparency, major challenges and delays are affecting the commissioning of Batch I projects (see Bankability, Manufacturing, and Enabling Environment sections). The grid-connected solar PV projects selected for Batch I were due for completion by January 2012. By early 2012, the Indian government had fined 14 PV project developers for failing to meet their commissioning deadlines and warned another 14.[38] By late March, 100 MW of PV projects were considered commissioned and the remainder were expected to be commissioned in April 2012.[39] As the Mission moves forward, compliance with deadlines will be a main focus, both to ensure that India actually meets its solar targets and to maintain the credibility of the government's policies, guidelines, and enforcement capabilities.

2. Batch II Projects: Approaching Grid Parity

India's Batch II reverse auction sent ripples through international solar markets. The lowest winning bid, by the French company SolaireDirect, was ₹7.49/kWh ($0.15/kWh) for a 5 MW plant.[40] This price was impressively lower than many markets had predicted, suggesting that solar energy could attain grid parity with traditional energy sources sooner than initially anticipated. Current Indian grid power prices in the top energy-consuming Indian states range from approximately ₹3.90/kWh ($0.08/kWh) in Andhra Pradesh to ₹5.90/kWh ($0.12/kWh) in Rajasthan, with a nationwide average of ₹4.70/kWh ($0.09/kWh).[41] Commercial and industrial power prices are generally higher, making the lowest winning bid of ₹7.49 ($0.15/kWh) tantalizingly close to the higher-end grid power price—just about ₹1.60/kWh ($0.03/kWh) short of grid parity and at parity with diesel.[42] Batch II's progress toward grid parity was highly praised during stakeholder conversations with the government, industry, and civil society groups.

Batch II awarded contracts to 22 companies with 27 total winning bids.[43] Welspun Energy, Azure Power, Mahindra, Green Infra and Jakson Power won multiple projects, with Welspun securing the maximum 50 MW of allotment for a single company. Green Infra and Mahindra secured 40 and 30 MW, respectively. All but three of the winning Batch II bids are for projects located in Rajasthan. The other three are in Tamil Nadu, Maharashtra, and Andhra Pradesh.

While larger companies, such as Reliance, did not participate as aggressively as expected during Batch II, some of these companies are undertaking big projects through state-level programs, such as Reliance's 40 MW Dahanu Power project in Jaisalmer, Rajasthan. The NSM has created momentum at both the national and state levels, as demonstrated by falling prices at the state level. For example, the Odisha Renewable Energy Development Agency (OREDA) selected a project with the lowest bidding price in the country in February 2012.[44] Some argue these state-level solar programs are more profitable than the national program due to higher feed-in tariffs and other state-level incentives. However, developers typically have more payment certainty through NVVN under the NSM.

Key Findings From Phase 1

As part of our assessment and analysis, CEEW and NRDC conducted several individual and group stakeholder discussions about experiences from Phase 1 of the Mission. Stakeholders included central government officials, developers, domestic banks, international financial and governmental groups, manufacturers, and community members. In later sections, this report presents in-depth analysis of bankability, manufacturing, and land use. Key findings highlighted by stakeholders during Phase 1 of the Mission include:

- The sophistication of solar energy stakeholders is increasing. However, a much greater degree of coordinated stakeholder action is needed to unleash the solar energy market's potential.
- As an overarching policy framework, the NSM aims to increase deployed capacity, enforce regulatory obligations for using renewable energy, create a manufacturing hub in India, and promote R&D for new solar technologies. These objectives will be achieved in different time frames and therefore should be correctly prioritized by the central government.
- Infrastructure, policy, and market conditions are shaping India's solar market differently from other solar markets. Unique attributes include the prevalence of ground-mounted solar parks, thin film PV technology used in more than half the projects, and low bid prices that make grid parity possible in the near future.
- Overall, stakeholders viewed the reverse auction bidding process as transparent and successful in driving down prices. However, financial institutions, civil society groups, and some developers suggested that in order to draw serious players with an ability to ensure project completion, and attract financing, project selection criteria should be more rigorous. Moreover, for the Mission to remain credible, financial due diligence and continuous monitoring are needed to ensure that commissioned projects are operational at contracted capacity and generating solar power that is transmitted to the grid.
- Indian bankers still perceive significant risks in the solar energy market and are largely hesitant to make substantial investments in solar technologies. International lenders, less risk-averse on the technology front, offer lower interest rates but remain skeptical about project completion. To bolster confidence among financiers, a range of funding channels, financial institutions, and other stakeholders must coordinate at program and project levels and provide ancillary support, such as R&D and skill development, to help the solar market mature.
- State policies have contributed to boosting solar projects in the past two years, especially in Gujarat and Rajasthan. For Phase 2, the central government needs to increase collaboration with states to facilitate RPO and REC compliance, project bidding, financing, power evacuation, transmission, and land acquisition.
- While the domestic content requirement (DCR) has garnered international attention and raised concerns among some foreign stakeholders, most developers do not identify it as a major barrier to project development. The case for a robust domestic manufacturing base rests on multiple objectives: energy security, technology development, energy access, ensuring product standards, attracting foreign investment, and creating jobs. Even so, many manufacturers expressed the view that the DCR, as currently structured, is not sufficiently stimulating local manufacturing. Manufacturers face other systemic limitations, such as poor infrastructure, lack of raw materials, an undeveloped supply chain, and lack of financing.
- Many developers have faced difficulties in obtaining clearances to convert land use for solar project development and encountered claims by other parties to government-allocated land. In terms of infrastructure, some developers have experienced difficulties with power evacuation and transmission lines to substations. Limited availability of skilled labor also remains a barrier to wide-scale project development.
- To protect local interests and the environment, developers and government agencies need to increase community involvement in the decision-making process, from project planning to operations.
- All stakeholders agree that while Phase 1 focuses on grid-connected projects, off-grid solar energy provides an even larger opportunity. They state further that stakeholders should work collectively to develop both public and private strategies for large-scale deployment of off-grid projects.

V. BANKABILITY: FINANCING SOLAR ENERGY PROJECTS

> *"Banks are still not well versed in providing loans for solar projects. They need to see a track record of delivery, and as yet there are not enough data for them to make decisions comfortably."*
>
> — Project developer, November 2011

India is one of the world's leading countries in installed renewable energy capacity and as a destination for renewable energy investments. In 2011 alone, approximately ₹51,000 crore ($10.3 billion)[45] was invested in the Indian renewable energy sector, more than one-third of it in solar projects. However, much greater investments are needed to meet India's full potential. Sufficient and timely mobilization of funds is fundamental to scaling solar energy in India. Despite increased understanding of the solar industry within pockets of India's conservative finance sector, commercial banks continue to perceive significant risk in solar investments and have not yet embraced solar as a mainstream investment opportunity.

For Phase 1, project developers were required to achieve financial closure within 180 days after signing a PPA with NVVN. Arranging financing for projects from external sources presented some challenges. Nonetheless, developers achieved their financing goals, accessing domestic and overseas funds and using their own company equity.

Equity financing might have helped to meet the relatively small scale of investment for Phase 1, but it cannot underwrite the targets for Phase 2. It is estimated that up to ₹100,000 crore ($20 billion)[46] will be required to reach Phase 2 implementation targets. Despite high levels of interest and invested funds, the challenge is to utilize government-supported schemes like the NSM to continue building confidence in the market and to facilitate the use of a variety of financing arrangements to meet requirements. Phase 2 will require an active governmental role to give financial players the confidence to invest in solar projects.

Engaging India's financial sector in the National Solar Mission is important for three main reasons:

- To help get Phase 1 projects off the ground and send a strong signal about the potential for a broader solar market;
- To develop confidence that funds are available to support scaling up the Mission; and
- To provide support for the overall solar ecosystem, but especially to support the development of manufacturing in India.

CURRENT FINANCING ISSUES: PERCEIVING MANY TYPES OF RISKS

Financial institutions identify several characteristics of the solar industry that are preventing NSM-supported projects from securing domestic financing, including these:

- Solar energy is a new sector and technology in India;
- High up-front costs result in a longer payback period;
- High domestic interest rates make overseas financing more attractive; and
- Uncertainty about the payment ability of financially distressed Discoms makes banks reluctant to lend to solar projects.

1. **New Sector and Technology:** India's solar energy market grew from 17.8 MW in early 2010 to more than 506.9 MW cumulative installed capacity in March 2012.[47] However, given the early stage of the industry in India, this has not yet translated into a track record of deployment. Banks have expressed discomfort with investing in "unproven industries" such as solar. Informational gaps and awareness issues exacerbating these perceived risks are discussed below.

"Non-recourse financing is the preferred financing structure, where the lending institutions would provide debt to a special purpose vehicle set up for the project, and would have a lien on the project's cash flow. However, as this structure does not provide recourse to the developers' balance sheet, banks require rock solid agreements for revenues from the projects."

— State Bank of India official, Business Standard, August 2010[48]

2. **High Up-front Capital Costs:** The up-front capital cost of a solar plant means interest rates have a significant impact on a project's total cost.[49] Despite lower recurring costs (and zero fuel costs), the high up-front capital expenditure means projects' financial returns on investments will extend over a considerable period of time.
3. **High Domestic Interest Rates:** India's rapid economic growth has been coupled with a period of high inflation and interest rates. This contrasts starkly with other major economies, where central bankers have maintained very low interest rates to stimulate a weak economic environment.[50] Many local developers seeking domestic funding have criticized the banks' high average lending rate of 11 to 13 percent annually.[51] Batch I developers using imported cells and modules indicated that they had been able to access overseas lines of credit of 9 to 10 percent annually.[52] The longer terms offered by overseas lenders (ranging from 15 to 18 years,[53] compared with approximately 10 years in India[54]) make foreign funds even more attractive to local developers. These longer-term loans provide greater certainty to the financier and the project developer, reduce borrowing costs, and match solar projects' longer gestation periods for return on investment.
4. **Payment Uncertainty:** Financiers we spoke to uniformly highlighted the poor financial health of energy-distribution companies (Discoms) as a big risk. This is a system-wide issue, not unique to the solar industry, and a number of Discoms in India are in a dire financial position, with combined losses posted in the vicinity of ₹29,000 crore (about $5.6 billion) in the 2009 to10 financial year.[55] Although innovative approaches like bundling thermal power with solar have reduced the cost burden on Discoms for already signed PPAs, uncertainty about the continuity of bundling and payment security schemes continue to plague stakeholders concerned about payments in the future.

LACK OF AWARENESS AND INFORMATION TO ADDRESS PERCEIVED RISKS

- Banks lack data about the solar market that could address these perceived risks. Deficiencies include:
- Lack of documentation of successful projects' track records;
- Lack of documentation of technological effectiveness;
- Lack of irradiance data; and
- Uneven dissemination of information to banks, and differing levels of understanding of the solar industry among potential lenders.

1. **Lack of Documentation of Successful Projects' Track Records:** Many stakeholders say that banks are uncomfortable investing in a sector (and a technology) that lacks a significant track record in India. Bankers are waiting to see not only whether commissioning deadlines are being met, but also whether performance claims can be achieved. However, data on performance are either not being generated or not being shared. MNRE is currently testing monitoring software to track project implementation progress through periodic developer reports.[56] Such a program could be used as a platform for collecting and sharing non-commercially sensitive information with a broader stakeholder base, or at minimum it could be used by MNRE to provide a periodic summary of project progress.
2. **Lack of Documentation of Technological Effectiveness:** Technologies employed under the NSM are still considered unproved in India, especially thin film PV technologies. Unlike wind turbines, which are certified by the Centre for Wind Energy Technology (C-WET) in Chennai,[57] there is no equivalent certification of solar components. Bankers have raised this issue as another factor that makes them reluctant to lend to solar developers.
3. **Lack of Irradiance Data:** In the first phase of the Mission, developers had to use generic irradiance data from sources like NASA. Most bankers do not yet have confidence that the generation estimations being used will be realized without site-specific irradiance data. Moreover, satellite-generated data must be verified against surface measurements, and seasonal variations have to be factored in as well to make informed decisions about site selection. MNRE, along with C-WET, are working to increase irradiance data by developing a network of 51 automatic solar resource monitoring stations around the country[58] and creating a detailed solar atlas. Solar radiation centers should be operational shortly as well, and MNRE is planning to publish the raw data from such centers.[59]

4. Uneven Dissemination of Information: With more than 170 banks and 80,000 branches,[60] it can be difficult to disseminate information uniformly through India's financial system. Additionally, to mitigate risk on large projects, banks often will syndicate loans, with one lead arranger distributing parts of the debt and the risk.[61] This syndication of loans may lead to other banks' leading solar transactions over time. Given the scale of the sector, however, an asymmetry in levels of understanding of the solar opportunity persists among banks. MNRE has facilitated discussions in an effort to increase awareness of and confidence in potential solar investments.

MIXED SUPPORT FROM SEVERAL SOURCES; COORDINATION NEEDED

With major information gaps and potential market failures, financial markets are not likely to warm up to the solar energy sector without strategic interventions to create a financing ecosystem. Although the Mission Document does not explicitly mention improving the bankability of projects, specific aspects of the guidelines offer policy support for finance sector engagement.[62] A range of funding channels, financial institutions, and other stakeholders exist in the financial ecosystem that would be relevant for the solar market as well. These financial stakeholders include multilateral funding channels, Indian public and private sector banks, public sector (non-bank) financial intermediaries (e.g., IREDA), bilateral funding channels, venture capital and private equity firms, new market mechanisms, and government fiscal support. But these institutions lack cohesion and information sharing. In order to increase bankability and overall solar market development, the different types of institutions need to be strategically coordinated at the program level and project level and in terms of ancillary support measures (see Table 4).

Many of the following current and contemplated regulatory programs need improvement or expansion to build

TABLE 4: A range of private and public institutions have a role in enhancing bankability and overall solar market development

	INSTITUTIONAL EXAMPLES	ACTUAL/POTENTIAL ROLE
STRATEGIC LEVEL	**Indian Public Sector (non-bank) Financial Intermediaries:** Reserve Bank of India; IREDA; Life Insurance Corporation	Priority sector lending; Concessional loans; Long-term debt
	Non-Financial Supporting Institutions: Solar Energy Corporation of India; Indian Banks' Association; Solar Energy Centre; BEE; C-WET	Channeling funds; Information provision; Skills; R&D; Component certification
	Multilateral Funding Channels: International Finance Corporation; Asian Development Bank; World Bank; Clean Technology Fund; Green Climate Fund (potentially)	Payment guarantees; Capacity building (esp. due diligence); R&D
PROJECT LEVEL	**Indian Banks:** Axis Bank; Bank of Baroda; ICICI; IDBI; Indian Overseas Bank; State Bank of India	Debt financing; Non-recourse project finance; Innovative finance (such as IDFs)
	Non-Bank Financial Institutions: IDFC; Infrastructure Debt Funds	Project finance; Support for market upscaling; Bridging finance gaps
	Overseas Funding: US-EXIM; US-OPIC; KfW (Germany); Multilateral Funding Channels	Concessional finance; Long-term debt
	Other: Venture Capital; Private Equity (Domestic and Overseas); Other early stage investors	Market entry support; Market upscaling; R&D
ANCILLARY MECHANISMS AND MEASURES	**Fiscal support:** NVVN/NTPC (Bundling); CERC (FiT); MNRE (Payment Guarantee Scheme)	Lowering costs; Incentivizing investment; Increasing market confidence
	Market Mechanisms: Carbon Market (CDM and Voluntary Market); Renewable Energy Certificates	Additional revenue support to incentivize investment
	Other: Bilateral Funding; Private Companies; Educational Institutions; National Skill Development Corporation	R&D; Skills development and training



5 MW grid-connected solar photovoltaic plant developed under the NSM by Welspun Solar AP Pvt. Ltd., installed in Pulivendula, YSR Dist., Andhra Pradesh.

CREDIT: WELSPUN SOLAR AP

confidence and awareness among financial groups, and thereby increase bankability:

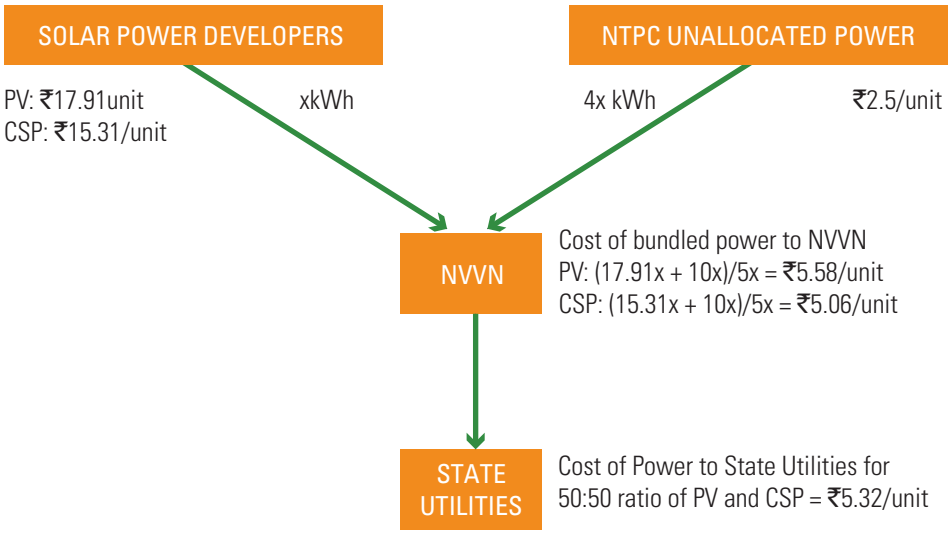
- Renewable Purchase Obligations & Renewable Energy
- Certificates;
- Priority Sector Lending;
- Preferential Tariffs;
- Bundling of Solar Power;
- Payment Security Mechanism;
- Clean Technology Fund;
- Infrastructure Debt Funds;
- Solar Energy Centre; and
- Solar Energy Corporation of India.

1. **Renewable Purchase Obligations & Renewable Energy Certificates:** Most stakeholders are enthusiastic about the benefits to the solar industry from wider renewable energy policy initiatives such as RPOs and the REC market.[63] Because renewable resource distribution is unequal across India, a system for trading RECs has been implemented to allow state "obligated entities" to meet RPOs.[64] Strong enforcement of RPOs will be fundamental to the success of the REC market and, in turn, will lower the costs of implementing solar projects. However, many stakeholders question whether state-level regulators will have the appetite to further burden already financially stressed Discoms through strict enforcement and whether REC prices will be sustained in the long term.

> ***"The single most important factor driving REC trading is state policy. Unless compliance is enforced on obligated entities according to policy mandate, they will not buy RECs."***[65]
>
> — Dr. Jayant Deo, CEO, India Energy Exchange

2. **Priority Sector Lending:** Many solar stakeholders advocate for priority sector lending for utility scale solar developments to reduce borrowing costs.[66] The Reserve Bank of India has the power to designate certain sectors as priority sectors for lending, toward which domestic banks must channel 40 percent of their net bank credit and foreign banks must channel 32 percent.[67] One challenge is that even among priority sectors, solar projects will have to compete with other industries.
3. **Preferential Tariffs:** CERC set a preferential tariff for solar for both batches of Phase 1 to encourage sector involvement and set benchmark returns for investors. The reverse auction mechanism led to a well-documented discount to the published tariff. Some stakeholders feel that such aggressive bidding eroded the perception of governmental regulatory support offered to ensure reasonable returns in a new sector, but most agree that the preferential tariff sets a price point from which market participants can establish their approach.

FIGURE 3: Bundling of Power Scheme: An innovative mechanism to reduce the price burden of solar



Source: See Mission Document, pp. 8-9 Global Investor Summit, "Jawaharlal Nehru National Solar Mission Process, Opportunities & Risk," presentation by State Bank of India, April 16-18, 2011: renewablemarketsindia.com/attachments/3359_Mr.%20Rajan%20Srinivas.pdf (accessed April 2, 2012).

NVVN has been designated as the nodal agency by the Ministry of Power to purchase and sell power during Phase 1 of the NSM. NVVN buys the solar power at a preferential tariff of ₹15.39/kWh ($0.30/kWh) from the solar PV power plant developers through a Power Purchase Agreement (PPA). NVVN is authorized to bundle up to 1,000 MW of grid-connected solar power with conventional power. NVVN is allocated four times as much MW capacity from the cheaper unallocated quota of thermal power from NTPC coal stations to bundle together with the more expensive solar power. This bundled power is provided to state utilities at rates determined by CERC. These state utilities can use the solar part of the bundled power to meet their RPOs.

4. **Bundling of Solar Power:** NVVN and MNRE's bundling of solar power with unallocated conventional power to reduce the potential financial burden on Discoms and consumers has been well received by stakeholders. The NTPC has access to a pool of unallocated coal, which will be bundled with solar at a ratio of 4:1. With a bundled unit of power costing about ₹5.32/kWh ($0.10/kWh), the Discoms can meet their RPOs without being burdened with a high-priced power source.[68]
5. **Payment Security Mechanism:** The Mission established an ₹486 crore ($98 million) Payment Security Mechanism (PSM) to cover nonpayment of PPAs by Discoms.[69] The PSM garnered a variety of stakeholder reactions. Some feel that the fund is inadequate for its purpose because of unclear processes, procedures, and requirements. Others have a high level of comfort with the fund since it has a well-estimated level of potential default and a well-structured tiered approach to dealing with payment default. However, stakeholders identified the mechanism's current lack of long-term certainty as a major concern.
6. **Clean Technology Fund:** The Government of India is seeking approximately ₹3683 crore[70] ($750 million) from the Clean Technology Fund (CTF), an international fund managed by the World Bank. Stakeholders have identified the following three areas where the CTF could be transformative in support of the NSM:[71]
   - Lowering the cost of financing and facilitating technology transfer in establishing solar parks;
   - Funding new and innovative technologies lacking financing under Phase 1; and
   - Contributing to a concessional financing pool for NSM Phase 1 and Phase 2 projects under 300 MW, to help overcome high up-front capital costs and lack of access to long-term credit at attractive rates.
7. **Infrastructure Debt Funds:** In July 2011, the government announced the creation of Infrastructure Debt Funds.[72] Most bankers with whom we consulted feel very positive about the funds since their mandate would be to increase the flow of long-term debt in infrastructure projects. Banks are reaching (or have reached) their power sector lending limits, and the creation of infrastructure funds will allow for solar sector investment without banks' exceeding their sector exposure limits.[73] The objective is also to develop a secondary bond market that could permit further refinancing of bank loans.
8. **Solar Energy Centre:** MNRE established the Solar Energy Centre in 1982 as a hub for developing solar technologies. Bankers note the need for a common platform where they can access information on project implementation and performance and interact with project developers on an ongoing basis. Although solar-related conferences are increasing, domestic bank engagement is still considered lacking by solar players. This Centre is underutilized as a potential resource to train and inform finance professionals on various aspects of solar technology.
9. **Solar Energy Corporation of India:** With an initial capital of ₹2000 crore ($403 million), the newly created Solar Energy Corporation of India (SECI) will increasingly take over NVVN's responsibilities and channel funds provided by multilateral institutions such as the Asian Development Bank. Stakeholders name SECI as potentially bringing together various fragmented components of the solar ecosystem to form the basis of an ongoing feedback loop to MNRE so that the latter may use such inputs to revise policies.[74]

Key Findings

Based on research and stakeholder discussions, we have formulated five key findings on bankability:

1. India's high interest rates impede project development, especially as the costs of solar plants are largely in up-front capital. Overseas financing is more attractive, both for lower interest rates and for longer-term debt, which match the longer payback period of solar loans.
2. Banks have a low comfort level with solar investments because of the lack of information available, and need more data and statistics on project development, deployment, and performance. They also need irradiance measurements from local settings, which are currently not recorded.
3. Financial institutions perceive solar energy in India as a riskier investment because it is a fledgling industry without a proven track record in meeting commissioning deadlines, performance benchmarks, and delivering power.
4. RECs represent an opportunity to support the solar market, but regulators need to strengthen the mechanisms for trading and enforcement since uncertainty about enforcement diminishes investor confidence.
5. Capacity building and networking among banks and other financial intermediaries are needed to increase information sharing and awareness within the financial community. MNRE has initiated activities toward awareness building and information dissemination, but much more can be done.

Key Recommendations

The banking sector needs a cohesive approach to reduce risk perception in what is still considered a nascent market. A number of actions can be taken to help improve bankability of projects and improve financial sector engagement. Some actions will require significant lead time, such as policy amendments to address high interest rates, while awareness-building and information-sharing activities can be more easily implemented. In addition to these recommendations, the government needs to continue innovating at a systemic level to reduce the high cost of finance in India. Based on research and discussions with stakeholders, we have formulated five key recommendations on bankability:

1. Regulators should diligently enforce RPO mandates and the REC market. National and state agencies should work together closely to ensure effective RPO and REC systems.
2. With the Reserve Bank of India and the Ministry of Finance, MNRE should encourage priority sector lending for large-scale solar projects to help reduce lending rates to as low as 10 percent and to provide higher employment potential for downstream solar activities.
3. To provide longer-term debt, the government should enhance funding mechanisms, including the proposed Infrastructure Debt Funds. To further reassure financiers, MNRE should share information on the payment security mechanism (PSM) and clarify how the PSM has been calculated to effectively cover potential default on payment.
4. Government agencies and private groups should provide solar resource and project deployment data as soon as they become available. MNRE and the Solar Energy Corporation of India (SECI) should work with developers to establish monitoring and reporting processes that can be implemented before Phase 2. SECI should become a central clearinghouse for all information dissemination relating to the solar ecosystem. A sharing platform for improved irradiance data should be created to disseminate information as it is generated.
5. The Solar Advisory Panel and leading financial institutions should create a network of solar finance leaders to develop bank products that support solar energy. Such a network could work together to syndicate loans, share information, and conduct workshops where bankers, developers, manufacturers, and EPC entities can come together to exchange knowledge and experiences about solar investments.

VI. MANUFACTURING: SUPPORTING A DOMESTIC INDUSTRY

> *"[T]he vast majority of these [solar] jobs are in finance, services, and installation—not manufacturing. Solar simply doesn't provide a lot of manufacturing jobs in any country, and the number is dwindling further with automation."*
>
> — Prof. Daniel Kammen, University of California, Berkeley[75]

A productive solar manufacturing base to provide domestic solar components is an important part of India's aspirations to become a major global solar player. The Mission aims to establish India as a solar manufacturing hub, to feed both a growing domestic industry as well as global markets. The NSM, while leveraging other government policies, looks to provide favorable regulatory and policy conditions to develop domestic manufacturing of low-cost solar technologies, with the support of significant capital investment and technical innovation.[76]

MANUFACTURING AMBITIONS: ISSUES AND OPPORTUNITIES

Prior to the NSM, Indian manufacturing of solar components was primarily export-dependent, with about 70 percent of cells and 80 percent of modules exported to Europe, the United States, Japan, and Australia.[77] The overall Indian solar market has grown significantly since the Mission's announcement in January 2010, and while this growth is positively influencing domestic production, manufacturing-related concerns remain. Discussion of such issues can be divided into the following three categories:

- Strategic benefits of a strong domestic solar manufacturing base within the broader solar ecosystem;
- Contextual analysis of the role manufacturing plays in job and value creation within India; and
- Domestic manufacturing issues within the Indian context.

BENEFITS OF A STRONG DOMESTIC SOLAR MANUFACTURING BASE

Solar manufacturing offers India a long-term opportunity to be a major global manufacturing nation, an avenue to achieve grid-parity with fossil fuel power generation, and greater flexibility to achieve a sustainable solar industry. Therefore, investing in solar manufacturing now can provide long-term strategic value for India. To be a dominant player in the global arena, India needs to make prompt, smart, and concerted investments in manufacturing.

Domestic solar manufacturing can also accelerate the march toward grid-parity in India. Local manufacturing using inexpensive local labor and reduced transportation costs due to shorter shipping distances can lower the final cost of local components.[78] A May 2011 KPMG report projected that grid parity for utility-scale solar (PV and solar thermal) could be achieved between 2017 and 2020.[79] Since then, Batch II bidding has driven the lowest bids to about ₹8/kWh[80] ($0.16/kWh), which is ₹2 to 3/kWh ($.04-.06/kWh) lower than the projections for 2011 to 2012.[81] In the short term, many stakeholders believe that building up domestic manufacturing by attracting foreign companies would invite advanced foreign technologies—thus augmenting domestic R&D efforts—and would significantly increase foreign direct investment.

Domestic manufacturing also provides a more flexible route to developing a sustainable domestic market. The greater the value chain participation by domestic players, the larger the amount of value that will be captured by the domestic market (rather than flowing overseas). Domestic manufacturing could also offer technical flexibility so that factories can be retooled to manufacture a different product more suited to prevailing or emerging circumstances.[82] Because heavy manufacturing investments can lock in technologies,[83] policies should enable market-based approaches that can efficiently target favorable technologies.[84]

Many stakeholders, particularly manufacturers considering setting up Indian operations and developers planning projects and future expansion, believe India's lack of a long-term, comprehensive, and practical solar plan is a major hurdle. While the NSM deserves much credit for laying the groundwork, widespread market uncertainty permeates the solar ecosystem, negatively affecting investments in manufacturing capacity.

INTERNATIONAL CONTEXT

Some countries are supporting their domestic markets to incentivize local solar manufacturing, for example:

Germany: To support its economy, Germany provides incentives to establish industrial facilities in its eastern region as well as support nationwide deployment.[85]

United States: To support its economy, the United States has provided manufacturing tax credits to companies producing clean technologies and is funding a number of programs through various federal agencies to support innovative manufacturing, including solar.[86]

China: To support its export-oriented economy, China provides low-cost financing and currency pegging.[87]

ROLE OF MANUFACTURING IN JOB AND VALUE CREATION

Although solar manufacturing has the potential to generate jobs and create value for India, our analysis indicates that manufacturing is not the sole, optimal route for short-term job and value creation. It also has associated environmental costs. Most important, the majority of jobs in the solar value chain are not in manufacturing (see Table 5). At least 50 percent of jobs lie downstream of module manufacture—in system design, integration, installation, operations, and maintenance.[88] These jobs are also locally bound.

For the Indian market, MNRE suggests approximately 50 percent of the value chain can be attributed to solar cells and modules.[96] Yet, anecdotal evidence from Reliance's 40-MW Dahanu solar PV project[97] suggests that the PV value breakdown under Indian conditions is roughly consistent with global estimates. In any case, significant value creation lies downstream of manufacturing.

Since half or more of the value could be captured through activities downstream, primarily targeting resource-intensive and investment-intensive manufacturing activities upstream is not optimal, especially at the outset. Focusing sufficient and complementary NSM efforts on the "low-hanging fruit"

TABLE 5: Distribution of Jobs Across Solar Value Chain

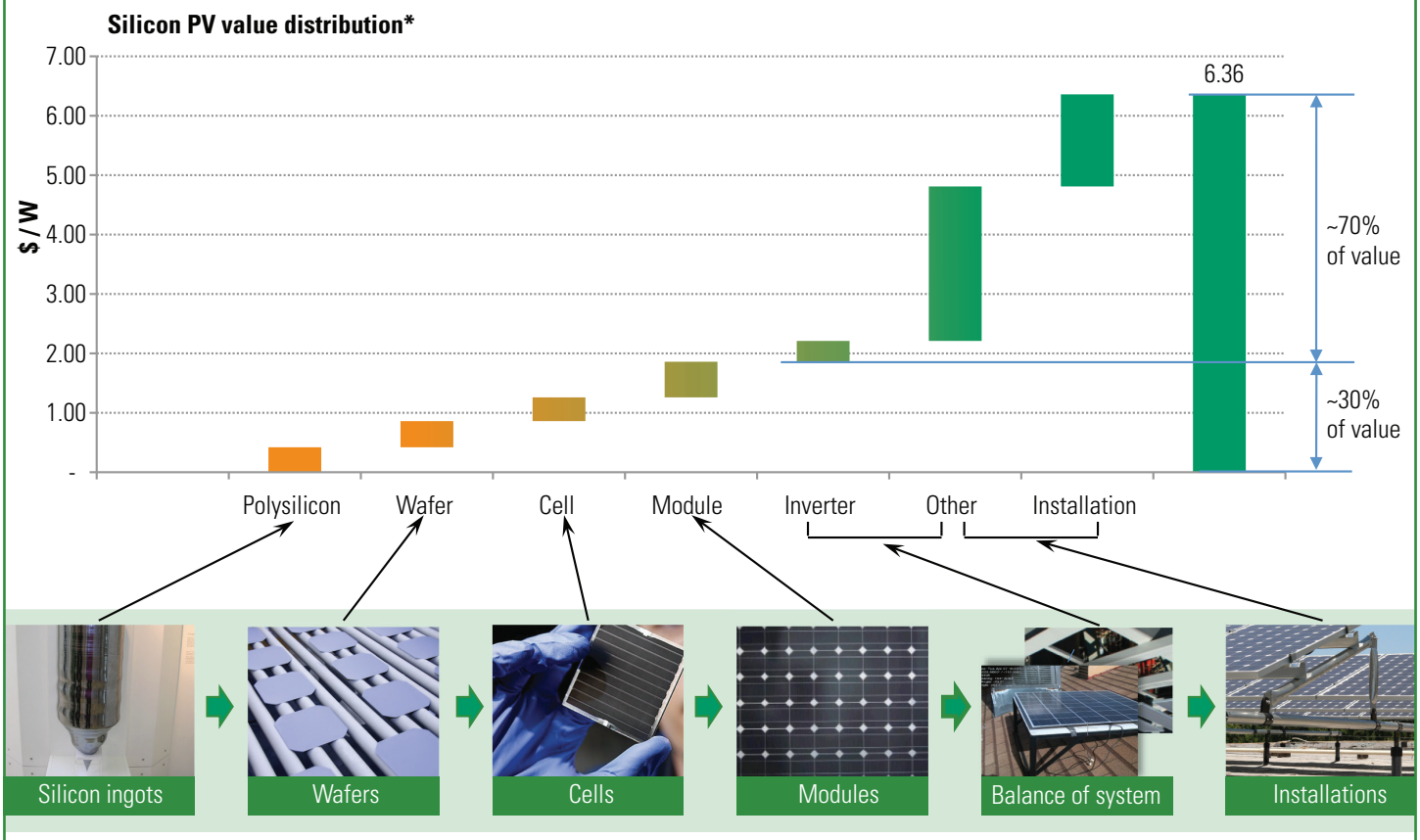
DATA SOURCE	MANUFACTURING	INSTALLATION	SALES	OTHER
EPIA/Greenpeace[89] (global average for 2010 to 2020)	25-40%	60-70%		up to 5%
Institute for Sustainable Futures[90] (global average for 2008)	24%	76%		
Solar Foundation[91] (U.S. average for 2010 to 2011)	15%	55%	26%	4%

In mature markets, value creation is also not concentrated in manufacturing.[92] Based on U.S. data, about 30 percent[93] of the value along the silicon PV value chain is attributable to cells and modules (roughly 20 and 10 percent, respectively). The remaining 70 percent of value lies downstream, in inverters, balance of system, mounting, site preparation, labor, and other needs such as engineering, permitting, legal processes, financing, and distribution (see Figure 4).[94] In the thin film sector, modules account for about 40 percent of the value, while the remaining 60 percent lies downstream.[95]

downstream may be more lucrative from both jobs and value creation perspectives in the short term. The full benefits of manufacturing require more time to take effect.

The entire solar manufacturing supply chain, but particularly upstream solar manufacturing, has environmental costs through its use of chemicals that are often carcinogenic and toxic.[98] Additionally, upstream PV manufacturing (especially silicon) is highly energy-intensive.[99] Robust environmental policy and safeguards are needed to safely expand manufacturing in India.

FIGURE 4: More than half the jobs and value generated lie downstream of modules



*Based on unsubsidized value chain analysis of U.S. silicon PV market. Roughly similar value distribution for thin film technologies.

Source: GTM Research prepared for Solar Energy Industries Association (U.S.A), "U.S. Solar Energy Trade Assessment 2011: Trade Flows and Domestic Content for Solar Energy-Related Goods and Services in the United States."August 2011; European Photovoltaic Industry Association and Greenpeace, "Solar Generation: Solar Electricity for Over One Billion People and Two Million Jobs by 2020" Sept 2006; EPIA, Greenpeace. "Solar Generation 6: Solar Photovoltaic Electricity Empowering the World." 2011; Rutovitz, J. and Atherton, A., Institute for Sustainable Future, University of Technology Sydney, "Energy Sector Jobs to 2030: A Global Analysis" 2009; The Solar Foundation. "National Solar Jobs Census 2011." 2011.

DOMESTIC MANUFACTURING ISSUES IN THE INDIAN CONTEXT

A range of systemic issues are affecting domestic manufacturing in India. The Indian solar manufacturing industry is not yet globally competitive in cost, quality, or product availability, hindering its further growth, especially in the absence of targeted assistance. Stakeholders identify several challenges, including these:

1. The burgeoning Indian manufacturing market is less technologically developed than other manufacturing countries.
2. Indian manufacturing is smaller in scale and more fragmented, leading to higher costs.
3. Such small-scale manufacturing also leads to lower-quality products.
4. Indian manufacturing is narrowly focused on only parts of the value chain, mainly midstream.

1. **Less Technological Development:** Countries like China and Taiwan are many years ahead of India in solar manufacturing, with their respective governments heavily investing in the industry since the early 2000s. This early action has allowed these nations to capitalize on the enormous growth in the solar market: China is now the largest producer of solar equipment, with 60 percent of global solar panel production capacity,[100] and Taiwan is the world's second-largest (see Table 6).[101] There is a downside, however. Both the Chinese and Taiwanese industries are extremely export-dependent (China exports 95 percent of its module production) and are now facing overcapacity problems.[102]

2. **Smaller Scale:** Solar manufacturing in India lags behind the rest of the world. The less-developed and smaller size of the country's solar manufacturing industry limits its ability to achieve economies at a scale typically observed globally.[103] Module manufacturing lines globally produce around 75 MW of capacity. Such a large scale allows bargaining power for procuring raw materials and the option of increasing production without constantly incurring investment costs for line expansions.[104] However, in India, module lines are only 10 to 20 MW,

forcing companies that wish to raise production to frequently make production line investments that result in a higher price per watt.[105]

3. **Lower Quality:** Developers and EPC contractors consider Indian products available for domestic consumption to be of lower quality compared with products from countries such as Germany. As one EPC contractor said, "It is just like [Indian] consumers preferring an imported refrigerator or air conditioner to a domestic one."[106] Also, some stakeholders feel that Indian products offer less value for money than comparable Chinese products. For example, one developer said, "Chinese products are so [inexpensive] that you can throw [one] away when it breaks and buy anew."
4. **Narrow Scope:** In addition to the smaller scale, many developers feel that the Indian solar industry currently is narrow in scope, focusing only on pieces of the solar supply chain, thus hampering attempts to achieve economies of scale. While India has many cell and module manufacturers, there is a dearth of producers of raw materials,[107] inverters, and balance of system components. As one developer put it, "Indian manufacturers can only optimize on production yields." The industry is now taking steps toward greater self-sufficiency.[108]

India, not by Indian companies per se. Our analysis of the DCR covers:

1. Stakeholder reactions to the DCR;
2. An emerging bias for thin film technologies due to the DCR exception;
3. Why the DCR's focus on upstream manufacturing may not be optimal; and
4. Proposed modifications to the DCR to address these unintended effects.

1. **Stakeholder Reactions to the DCR**
Many solar industry players, particularly in India, have praised the NSM's DCR as transparent and necessary. They believe that this opportunity for India to become a major player in the solar field depends on strong support for local manufacturing. Otherwise, with many established foreign players currently dominating the field with cheap cells and modules, there will be little incentive to manufacture these solar components in India. Some fear that without a DCR, India will not be able to achieve the Mission's goal of creating a local solar market while reducing dependence on foreign imports.

TABLE 6: Country Comparisons of Solar Manufacturing Policies, Production, and Capacity

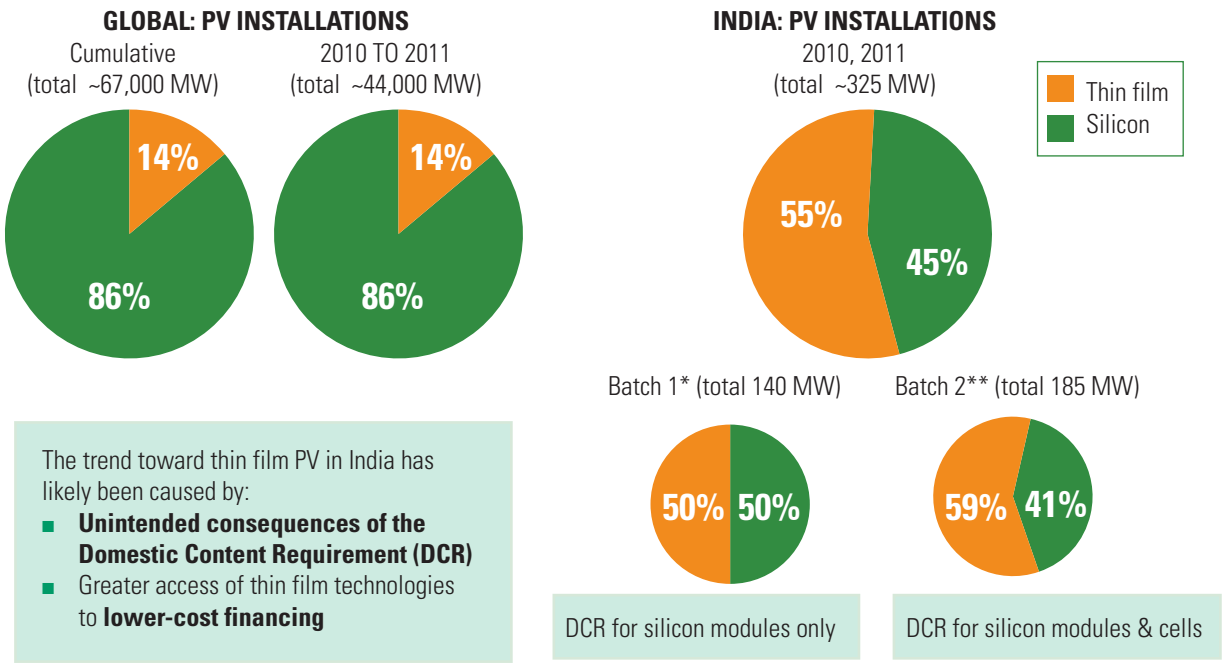
COUNTRY	START OF MAJOR SOLAR INDUSTRY SUPPORT	SOLAR MANUFACTURING PRODUCTION IN 2010 (MW)[109]	SOLAR MANUFACTURING CAPACITY IN 2010 (MW)
China	2005 (Renewable Energy Law)[110]	13,018	17,500—20,000[111]
Taiwan	Before 2001(MOEA)[112]	3,449	27,200[113]
Germany	1999 (EEG)[114]	2,656	3,050[115]
United States	1975 (in response to oil crisis)[116]	1,253	1,333[117]
India	2010 (NSM)	470	2,000[118]

DOMESTIC CONTENT REQUIREMENT'S EFFECTS ON MANUFACTURING

The domestic content requirement (DCR) is turning out to be one of the Mission's hot-button elements, garnering a wide spectrum of stakeholder reactions varying from high praise[119] to hostility.[120] Although the initial Mission Document did not mention a DCR, the subsequent Mission Guidelines for both Phase 1 batches have included a local content requirement to promote the Mission's goal of creating a solar manufacturing industry.[121] The Mission Guidelines for Phase 1's Batch I required that crystalline silicon modules be manufactured in India, and this requirement was extended to silicon PV cells and modules for Batch II.[122] Thin film technologies are currently exempted from the DCR and do not have to be manufactured domestically.[123] The DCR requires only that crystalline silicon components be manufactured within

In contrast, other stakeholders criticize the DCR as being responsible for unaffordable projects that are then unable to achieve scale. These stakeholders believe that the DCR is driving up project costs by prohibiting access to cheap solar components and technology abroad, thereby creating an uneconomical rate of return. They fear the lower economic viability of the NSM silicon PV projects may slow the rate of solar installations initially, until the infrastructure for local manufacturing is established, and believe it undermines the Mission's goal of low-cost solar power. An inability to commission affordable solar projects in the short term may keep the NSM from achieving its megawatt targets. Additionally, some stakeholders believe that if India were to impose a DCR on silicon wafers and ingots soon, the domestic manufacturing industry would likely fail to scale up quickly and inexpensively enough to serve the demand.

FIGURE 5: The mix of PV technologies deployed in the Indian market is markedly different from the mix deployed globally



*Based on information on 28 Batch I PV projects totaling 140 MW, as of January 2012, obtained from NVVN. **Based on a subset of 9 PV Batch II projects totaling 185 MW from publicly available information and NRDC/CEEW conversations with developers as of February 2012. Note that developers can change technology until MNRE deadlines.

Sources: MNRE 5 Year Plan; GBI Research; PV News and GTM Research May 2011; European Photovoltaic Industry Association 2011; Down to Earth, "National Solar Mission: bidders quote low tariff, bag projects" Dec. 7, 2011: http://www.downtoearth.org.in/content/national-solar-mission-bidders-quote-low-tariff-bag-projects; Hindu Business Line, "GAIL, Mahindra, Welspun to develop solar PV projects" Jan. 2, 2012: http://www.thehindubusinessline.com/companies/article2769056.ece; Hindu Business Line, "Solar mission: We wanted to send out a message, says Solairedirect" Dec. 7, 2011: http://www.thehindubusinessline.com/companies/article2695432.ece; The Economic Times, "Welspun Solar": http://economictimes.indiatimes.com/topic/Welspun-Solar; Energy Alternatives India: http://www.eai.in/.

"It's a disaster in the making. I'm feeling a bit of anguish because we want solar to succeed, but we need fair competition."

— K. Subramanya, CEO, Tata BP Solar[124]

2. Emerging Bias for Thin Film Technologies

Many stakeholders believe that, contrary to its intentions, the DCR is creating an uneven playing field and has helped propagate significant overcapacity in the domestic silicon PV manufacturing industry. Since thin film PV technologies are exempted from the current local manufacturing requirement, many solar players believe the DCR is not creating the right conditions for domestic manufacturing in India.

Two factors are leading to a thin film bias for NSM PV projects. First, developers have greater access to low-cost international financing for thin film technology due to export requirements. Second, the DCR exemption for thin film imports is leading to lower module costs than domestically manufactured crystalline modules.

The global solar market does not reflect this thin film trend. Thin film deployment both cumulatively and in the past two years has been approximately 14 percent of total PV deployment globally.[125] In contrast, thin film technology had been used for more than 70 percent of all installations through November 2011.[126] The most recent data available from NVVN indicates that thin film technology will be used in about 50 percent of approximately 140 MW to go online by 2012 under the NSM's first batch of projects.[127] A similar bias is expected in the second batch (based on available information for a subset of projects) (see Figure 5).

Unfortunately, the Indian thin film bias appears to have caused significant overproduction of local silicon PV, about 80 percent of manufacturing capacity.[128] Our discussions with manufacturers reveal that silicon-based manufacturers have failed to benefit from the DCR despite robust and growing market demand for PV components.[129] In the Indian market overall, low-cost Chinese imports and thin film backed by low-cost international financing are dominating orders.[130] The DCR as designed and implemented appears to have been largely ineffectual to date.[131]

"As implemented, this protectionism has so far merely distorted the market in favor of thin film."

— Alan Rosling, Founder, Kiran Energy[132]

3. DCR's Focus on Upstream Manufacturing

Since more than half of the value and solar-related jobs are created downstream of module manufacturing, the DCR's current sole focus on cell and module manufacturing is not the best way to maximize job and value creation. Many solar players we spoke to want a policy that also focuses on downstream activities. This could increase the Mission's employment-generation potential and boost the captured value for solar PV significantly. The NSM, in its quest for manufacturing, must not overlook the enormous jobs and value generation potential of the services-oriented sections of the value chain, downstream from modules. A healthy domestic module manufacturing industry, at the center of the supply chain and at the divide between technology-intensive steps upstream and labor-intensive steps downstream, could serve as a catalyst to further domestic development of the industry. In other words, if a domestic module manufacturing industry is established, market players can more readily choose to venture into downstream service-based activities or vertically integrate into upstream manufacturing. Additionally, there is potential for developing manufacturing capabilities in ancillary industries, such as balance of system equipment.

Finally, as the Mission Document outlines, government incentives should ideally be technology-neutral, particularly as the solar industry continues to evolve.[133] Policies should remain flexible to avoid locking the country into a legacy technology that cannot respond to advances in the industry.[134]

4. Proposed Modifications to the DCR

As a policy instrument, tailored domestic content requirements have had modest success in other countries (see Table 7), and a suitably tailored DCR

TABLE 7: Domestic content requirements or incentives have had some success globally

	CHINA	ONTARIO, CANADA	U.S.	ITALY
Stipulation vehicle	National Development and Reform Commission Order 1204	Ontario Power Authority Feed-in-Tariff Program Rules	American Recovery and Reinvestment Act (ARRA), "Buy American" Provisions	Quarto Conto Energia (the Fourth Energy Plan)
Launch year	2003	2009	2009	2011
Industry benefited	Wind	All renewable energy industries	All manufacturing industries	Solar
Details of local content requirement	All wind farms developed in China, private or public, to have locally made components. The percentage of local content started at 50 percent in 2003 and was increased to 70 percent in 2004.	Developers are required to have 50 percent of their project costs come from Ontario goods and labor at the time they reach commercial operation. Increased to 60 percent from January 2011.	All public projects backed by ARRA funds must use ARRA-compliant products. If the domestic content of a product is over 50 percent and manufactured within the U.S., it can be considered ARRA compliant.	A bonus of 10 percent on the feed-in tariff when 60 percent of the material costs of an installation are from products manufactured in the European Union.
Impact	*Worked effectively:* By the time the condition was revoked in 2009, China had transformed from a marginal player to being the dominant manufacturer of wind turbines in the world.	*Working well:* Companies like Silfab, Suntech, and Schneider set up manufacturing bases in Ontario.	*Mixed results (for solar):* Most of ARRA-compliant companies are foreign players, such as Kyocera, Sharp, Sanyo (Japan); Suntech (China); Schott (Germany). At the same time, most U.S. players, such as FirstSolar, Sunpower, have bulk of manufacturing outside U.S.	*Impact as yet unknown:* Likely to benefit manufacturers in Germany and Spain. FirstSolar qualifies. Norway included as an exception.

Sources: **China:** Lewis, J.I. "A Review of the Potential International Trade Implications of Key Wind Power Industry Policies in China", prepared for Energy Foundation: http://www.resource-solutions.org/pub_pdfs/China.wind.policy.and.intl.trade.law.Oct.07.pdf; The New York Times, "To Conquer Wind Power, China Writes the Rules" December 14, 2010: http://www.nytimes.com/2010/12/15/business/global/15chinawind.html.

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Solar photovoltaic modules manufactured by Solaria Corporation, installed in a solar power plant in India.

CREDIT: SOLARIA CORPORATION

could be successful in India. The flexibility built into the phased NSM guidelines allows such changes, though modifications to guidelines should be balanced against the benefits of predictable and stable policies for the solar sector.

In addition to expressing the need for a market-based approach to industry development, many stakeholders have proposed DCR modifications to address perceived weaknesses. Rather than an "absolutely restrictive" policy that cordons off the Indian market to foreign parties, some solar firms have suggested a preferential tariff to incentivize domestic manufacturing.[135] Another idea is to have the DCR require only that a certain percentage of the value of solar components be manufactured in India (like the DCR for solar thermal technologies). However, this route raises potential monitoring obligations for MNRE as the nodal agency and could increase the transaction costs for manufacturers and government officials. A smaller cross-section of foreign stakeholders assert that good manufacturing policy is not compatible with good trade policy and question the use of any market-restrictive policies at all.

As India's solar industry and broader economy continue to grow, its actions will have greater international implications. The current DCR has elicited a mixed international response and has raised possible World Trade Organization (WTO) concerns,[136] which a revised DCR may not be immune from either. India will increasingly need to consider international reactions as it transitions from being a marginal manufacturer to a major exporter. Under multilateral trade rules, if policies discriminate against foreign entities *and* are found to have adverse impact on them, then such measures can be disputed at the WTO. However, the purpose of the policies also matters. If the policy exists purely to serve mercantilist, export-oriented interests, then clearly it would be challenged. But if its purpose is to strengthen and develop a nascent clean energy sector, in part to protect the environment, then exceptions under WTO rules could be invoked.[137] In India's case, support for solar manufacturing seems, at least so far, to have energy access and energy security imperatives, and little to do with promoting exports at the expense of foreign entities. Moreover, imports of solar equipment do not appear to have been adversely affected. At some point in the future, should India become a major exporter, it would have to contend with potential international opposition to its DCR rules.

Key Findings

Based on research and stakeholder discussions, we have formulated five key findings on the solar manufacturing sector:

1. Phase 1's domestic content requirement has contributed to shifting the market toward thin film PV projects due to their exemption from the DCR. Fifty-percent of Batch I projects use thin film and crystalline cells, a larger proportion than in the global PV market. Batch II projects use even more thin film technology, probably because Batch II requirements for domestic crystalline cell manufacturing have made lower-priced, imported thin film, often coupled with low-cost international financing, more attractive to developers.
2. The Phase 1 domestic content requirement as currently structured has not effectively created the market conditions for local solar PV manufacturing envisioned by the NSM. The DCR has not created a level playing field. Instead it has contributed to a strong thin film bias and has possibly been a detriment to Indian crystalline-based manufacturing.
3. The Indian solar cell manufacturing system requires systemic improvements in infrastructure, domestic low-cost financing, and raw materials.
4. More than half the jobs in the solar value chain and value creation are not in solar manufacturing, nor specifically in cell and module manufacturing. Severe environmental costs linked to unregulated solar manufacturing also exist.
5. A modified DCR could have a positive influence on domestic manufacturing if it is technology-neutral and not overly restrictive.

Key Recommendations

An overarching, comprehensive, and long-term policy framework that integrates policies across India and provides necessary support for the entire solar market—including manufacturing—is necessary to achieve the NSM's goals. Based on our research and stakeholder discussions, we have formulated five key recommendations for developing a solar manufacturing hub in India:

1. The central government, with stakeholder input, should explore whether incentivizing policies with a broader scope than solely cell and module manufacturing would capture more value and create more solar jobs within the Indian context.
2. MNRE should tailor the DCR to be technology-neutral and market-enabling. MNRE could explore two options: (a) a DCR requiring that all PV modules be manufactured in India, uniformly enforced across all PV technologies, or (b) a DCR specifying that a certain percentage of solar PV components be manufactured in India.
3. To avoid being restrictive and to lessen the potential for international controversy or trade disputes, MNRE could consider incentives other than a DCR, such as a preferential tariff, to promote domestic manufacturing.
4. Manufacturers should strengthen existing networks, such as SEMI, to explore ways to ease barriers to manufacturing in India. The manufacturing networks could develop policy proposals to address natural resource, finance, and trade limitations.
5. MNRE should work with the Ministry of Environment and Forests to strengthen environmental safeguards to ensure that manufacturing can continue to grow rapidly while protecting community health and the environment.

VII. ENABLING ENVIRONMENT: FACILITATING LAND ACQUISITION, PERMITTING & POWER EVACUATION

> *"One of the immediate goals of Phase 1 of the Solar Mission is to create an "enabling environment" for solar technology penetration in the country. An enabling environment is created by fostering rapid deployment of solar energy nationwide by creating favorable conditions to develop solar projects."*
>
> — Mission Document[138]

HOW TO CREATE AN ENABLING ENVIRONMENT

Our discussions focused on four main areas affecting timely project implementation. These areas extend beyond the more project-specific bankability and manufacturing concerns:

1. Land acquisition;
2. Power evacuation;
3. Community involvement; and
4. A comprehensive National Solar Mission implementation plan.

1. Land Acquisition: Clearances and Irradiance Data

Several project developers have noted barriers to acquiring land and obtaining requisite clearances. The actual cost of purchasing land is not a significant barrier, as land costs are usually 5 percent of total project costs. In fact, some developers indicate that they would be willing to pay more for land. Rather, projects often suffer delays given the slow rate at which local authorities convert land use designations from agricultural to non-agricultural. After an allocation under a lease or sale by the state government, weeding through local claims on land presents another hurdle.

Locating projects in areas of high solar irradiance, close to the power grid and with adequate resources and infrastructure, is also a challenge, especially given India's limited geographic mapping and limited data on solar irradiance. The grid-proximity and irradiance challenges are compounded by traditional difficulties that nearly all energy projects face, such as poor grid infrastructure, transmission problems, and chronic power shortages.

2. Power Evacuation: Grid Connectivity and Proximity

There is currently a mismatch between the speed with which power projects can be set up and the time it takes to provide the supporting infrastructure. Grid connectivity for utility-scale solar projects depends on grid capacity, proximity, and availability. Many project developers have difficulties siting projects in areas with sufficient grid capacity, resulting in increased costs and project commissioning delays. Power availability affects project operation and power generation. To address adequate capacity and proximity, stakeholders have debated whether the government should invest in substations and transmission facilities before projects were set up. Yet for current projects in Gujarat or Rajasthan—where the majority of solar PV is being deployed—grid connectivity has not been raised as a major issue, in part because of the states' approach to using solar parks. Decisions on siting the solar parks are, in turn, based on connectivity to the grid. As the Indian solar market grows and larger capacities are commissioned, especially during Phase 2 of the Mission, planning for future grid upgrades must receive emphasis in advance, so that the infrastructure is available as projects are commissioned.

The "last-mile" infrastructure—how solar projects are physically connected to the grid—is a source of confusion. Some developers and officials identify a lack of clarity on who bears the cost of last-mile infrastructure, state utilities or developers. For some developers, who had not anticipated the costs of last-mile construction, project costs have exceeded allocated budgets. Who bears the additional cost for the last mile seems to vary according to supporting state or central government policies. Implementation support by state and central authorities could clarify which entity bears the last-mile infrastructure cost. The NSM designates that state agencies and utilities are responsible for creating

TABLE 8: Solar project land development options

Land Ownership	Key Features	Advantages for Developers	Disadvantages for Developers
Developer Purchased & SPV Owned	Project developer purchases land and special purpose vehicle (SPV) entity owns the land as an asset on its balance sheet	Full developer flexibility in choice of location according to solar resource and other siting criteria Use of land as part of collateral for project finance Option of sale or renewal at end of project life	High upfront costs Challenging purchase process if land use must be changed, e.g., from agricultural to non-agricultural or multiple land claims Developer has full responsibility for site due diligence and permitting
Lease by Government	Government purchases, acquires or otherwise earmarks land for solar development Lease periods typically match project life, e.g., 30 years	Lower upfront investment in land cost Ability to spread land costs over project lifetime and matching of costs with revenues Availability of land with pre-approved clearances and permits Flexible government incentives and leases	Lesser flexibility in siting and choice of location Limited opportunities to lease government land Increased government interactions and processes
Solar Park	Government or a private developer purchases or acquires land Solar parks usually include incentives such as permits for developers and provide dedicated power infrastructure	Solar parks provide economies of scale in procurement, permitting, and development of power Well planned solar parks can allow quicker and more reliable project execution with fewer implementation risks for developers	High reliance on solar park developer or government for correct siting and assessment of solar resource Potential cost increase and weaker negotiating position with respect to government and solar park developer

the infrastructure for evacuating power from project sites to transmission lines. There is no additional national-level support for power evacuation. The cost for last-mile infrastructure can be 5 to 10 percent of total project costs, according to a 5 MW Phase 1 developer. Yet as project sizes increase, the cost of last-mile infrastructure becomes a smaller percentage of the total project cost and may be more readily absorbed.

3. Community Involvement and Habitat Protection

Local communities, largely village-based, are critical to the success of solar projects. Developers and local officials must involve village members in all stages, from planning to operation. Villagers' concerns and preferences need to be considered to maximize the benefits of solar power and to avoid adversely affecting communities in the scale-up of operations. Successful solar projects are integrated into the community fabric, providing local jobs and building community pride in renewable energy development. Ineffective community involvement can create contentious conditions for permitting and for solar operations.

Solar PV projects, once installed, can provide significant benefits to local communities and cause less pollution than a coal-fired power plant. However, solar development can have negative social and ecological impacts if poorly planned. With 5 to 10 acres required per megawatt,[139] ground-mounted solar power is a land-intensive option. Currently, the majority of Phase 1 grid-connected solar projects are in remote locations, where the primary contentious issues are conflicting land claims and land allocation for grazing. Opposition to living close to major infrastructure projects, which has been an issue in other countries, has not yet been seen on a large scale in India. However, more social and ecological issues may surface as the NSM ramps up. As the solar energy market matures, it is critical that government policies and developers minimize impacts on the local communities and ecosystems.[140]

Local communities can be beneficiaries of solar development, but they stand to lose if not sufficiently and correctly integrated in the development process. An appropriately designed land-use policy minimizes land conflicts and incorporates multiple uses of solar-sited land. Developers must consider how solar projects can help provide energy to local citizens, who are often impoverished and in remote locations. Moreover, local communities need to be empowered and integrated into planning processes that



5 MW grid-connected solar photovoltaic plant developed by Punj Lloyd Infrastructure under the NSM and constructed by Punj Lloyd Delta Renewables in Bap village, Jodhpur, Rajasthan.

CREDIT: PUNJ LLOYD

take into account their concerns and preferences. This will engender greater community acceptance and enthusiasm for solar energy projects.

4. Comprehensive Policy Framework: 20-GW Road Map

While the National Solar Mission's 20-GW target and related policies have effectively launched a nascent market, several stakeholders have identified the need for a comprehensive road map that provides certainty for the private sector and communities. At a minimum, government policies must provide clarity on the number and type of projects expected to come online in the future to allow stakeholders to confidently make long-term investments. Moreover, stakeholders suggest that explicit strategies are needed in four main areas:

a. Supporting the entire solar energy supply chain;

b. Research and development (R&D);

c. Skilled labor force; and

d. Favorable customs and excise duties.

a. Supporting the Entire Solar Energy Supply Chain: Stakeholders cite the need for more planning and predictability in solar energy growth. Some suggest that instead of the current broad ranges of target solar capacity in multiyear phases, the government should specify annual benchmarks for solar generation capacity. Others propose a timeline for regular bidding and reverse auctions to complement the annual benchmarks. Government policies focused on broader planning issues such as siting, raw materials and resource availability, proximate location of interdependent industries, cluster development, and environmental impacts are also needed. Leading solar manufacturing nations often develop clusters of interrelated activities to facilitate knowledge, skills, R&D, and network synergy.[141] Recognizing that the solar energy system requires not only cells and components but also inverters, power equipment, and other system equipment, stakeholders suggest expanding government policies to cover the solar project's entire supply chain. For example, while renewable-energy power storage is currently not cost-efficient, storage technologies could arguably be transformative for India and encourage more investment in the future.[142]

b. Research and Development: Solar R&D is needed to improve domestic manufacturing and services and make India globally competitive. R&D will help develop new technologies and adapt global technologies to Indian conditions (the labor market, weather patterns, maintenance and connectivity issues, etc.). Early and significant investment in R&D is essential for India to become a large solar market.

c. Skilled Labor Force: Stakeholders identified a shortage of manpower with skills relevant to the solar industry, which poses even greater challenges to rapidly scaling solar energy.[143] Government policies geared toward

developing a skilled workforce are needed. Jobs related to solar energy include site preparation, design, permitting, legal processing, financing, mounting and installation, engineering, and distribution.

d. **Favorable Customs and Excise Duties:** Stakeholders suggest modifying customs and excise duties to be more favorable to solar energy development. While customs duties are levied on certain raw materials required for local manufacturing, there is no duty on finished products such as modules (when imports are allowed).[144] This inverted customs structure disadvantages domestic manufacturers.[145] Some stakeholders suggest removing all customs duties on raw materials, or at least imposing smaller ones.

POLICY ANALYSIS: IMPACTS AND GAPS

Several national and state policy instruments support growing "Solar India" under the Mission more broadly. Some instruments have been successful, while others need modification.

SOLAR PARKS: Leading states, like Rajasthan and Gujarat, have developed areas of land zoned for multiple solar project development. Many solar parks have been effective at reducing costs, facilitating permitting, and providing power evacuation and transmission. In early 2012, MNRE created the Solar Energy Corporation of India as a vehicle to create solar parks.

POWER CONNECTIVITY: Key states have announced policy support for power evacuation from renewable energy. Rajasthan disbursed ₹2900 crore (about $5.6 million) to develop power evacuation for renewable energy. Gujarat and Maharashtra have policies to improve state utility distribution companies to support solar power evacuation.

SPECIAL INCENTIVE PACKAGE SCHEME: The Semiconductor Policy 2007[146] encourages semiconductor manufacturing, including for solar PV. The Special Incentive Package Scheme (SIPS) offers tax rebates and capital subsidies ranging from 20 to 25 percent, but imposes minimum investment thresholds. SIPS has been marginally effective, and modifications are being considered.

CUSTOMS & EXCISE DUTIES: Customs duties for solar products support in part the NSM's aim to build domestic manufacturing. Currently Indian customs laws impose[147] no duties on finished photovoltaic modules,[148] 21.5 percent duty on inverters,[149] 5 percent duty for equipment imported for initial stages of solar projects,[150]12.8 percent duty on imports of certain materials used to manufacture cells or modules in India,[151] and no duties on toughened glass and silver paste imported for manufacture of solar cells or modules.[152] India exempts from excise duties all items for machinery, instruments, and other equipment required for initial solar power project development, subject to certain conditions.[153]

RESEARCH AND DEVELOPMENT: The NSM encourages participation of premier institutes like the Indian Institute of Technology, Ministry of Human Resources Development, and Ministry of Labour to develop a skilled workforce across various levels.[154] For example, IIT Bombay's National Centre for Photovoltaic Research and Education (NCPRE), launched in 2010, focuses on cutting-edge PV research to support global solar energy development.[155]

Related issues raised by developers include delays in customs notification and excise duty exemption certificates and the requirement to apply for each component separately. MNRE has taken steps to streamline exemption certificates by classifying components for which developers can apply for exemptions without first signing a power purchase agreement. In terms of incentives, the Indian government recently modified the Special Incentive Package Scheme under the Semiconductor Policy 2007 to offer capital subsidies for solar manufacturing and semiconductors more generally.[156] When the policy was announced in 2007, the Indian industry claimed that the incentives (20 to 25 percent) were too meager in light of the requisite multi-billion dollar investment, particularly when compared with China's and Taiwan's 50 percent subsidies.[157] Customs duties and subsidies illustrate the interconnectedness of government policies and industry action and the need for a holistic approach.

Key Findings

Based on research and stakeholder discussions, we have formulated five key findings for an enabling environment:

1. Land acquisition issues, including siting, clearances, and grid proximity, are delaying projects. Currently, land costs represent a small share of total project costs and are not the most significant barrier to land acquisition. While in early stages, solar parks have proved to be effective in facilitating project development and reducing delays.
2. Several developers and financiers have identified power evacuation and access to the grid as issues of concern, and in their absence, it has been difficult to secure financing for projects.
3. Developers are confused about which entity or agency is responsible for last-mile infrastructure, resulting in project delays.
4. Actively involving communities in every stage, from planning to operation, will strengthen solar energy projects. Project developers already recognize that there are co-benefits that can be shared with local communities and that problems can arise if local communities are not engaged throughout the process.
5. To enable industry progress, developers, banks, and other stakeholders have identified the need for a long-term implementation plan that focuses on the entire supply chain, investment in research and development, labor force training, and the provision of sufficient and customized financial incentives.

Key Recommendations

Based on research and stakeholder discussions, we have formulated five key recommendations for an enabling environment:

1. The central government should closely and systematically coordinate with state governments on project allotment, land acquisition, and project development, particularly for the larger Phase 2 projects. Specifically, MNRE should work with states to develop effective land allocation strategies for solar projects, including strategies to facilitate siting and planning requirements.
2. MNRE should also collaborate closely with the Ministry of Power to plan for transmission infrastructure upgrades within a long-term power planning framework focused on scaling renewable energy.
3. Before bidding for Phase 2 projects begins, MNRE and developers should work together to resolve whether last-mile infrastructure costs should be included in project estimates.
4. To strengthen solar projects, developers should integrate local communities at the planning stage through regular community meetings and engagement.
5. The solar industry should create a network of solar energy groups focused on resolving common industry concerns, interacting with government agencies, developing solutions for the entire solar supply chain, investing in research and development, and increasing the solar energy workforce.

VIII. CONCLUSION

India has a tremendous opportunity to capitalize on its natural solar resources to address growing energy deficits in a sustainable manner. The Jawaharlal Nehru National Solar Mission has established the framework within which an ecosystem for a solar industry in India can develop. The objectives of the Mission are manifold: increasing deployed capacity, enforcing regulatory obligations for using renewable energy, creating a manufacturing hub in India, and promoting R&D for new solar technologies. Achieving these objectives will take different amounts of time. Having initiated growth in the nascent solar industry, the Mission's role will now be to strategically prioritize these multiple objectives to ensure that the many entities within India's solar ecosystem perform in a coordinated way to establish India as a global leader in solar energy.

This report's analysis finds that each key aspect of the solar ecosystem—commissioning projects, increasing their bankability, developing a manufacturing base, and creating an enabling environment—faces issues that can be improved by the involved stakeholders and the NSM. While the Indian government and solar energy stakeholders have made significant progress, much more needs to be done.

The most important intervention would be to create a common platform, under the Mission, to bring together multiple stakeholders to review progress under the Mission and learn from both successful projects and those facing challenges. Toward this end, implementing three key policy priorities this year would enable strong growth under the Solar Mission:

Benchmarks, Transparency, and Monitoring: There is an urgent need to increase the level of information available on the Mission's progress. The government should enforce periodic updates on each project's progress, without which its project selection process and due diligence will be called into question. The government should adopt a common definition of "commissioning" as well as common benchmarks for commissioning projects under the state and national Missions. Moreover, for financiers to become more familiar with technologies, and for component standards to be closely monitored, project technology choices need to be transparent. Finally, irradiance data must be made publicly available to increase confidence and investment in the solar market.

Strategic Financing: Central and state government agencies, with MNRE's leadership, should develop a strategy to optimize the roles of different financial institutions. As the market matures, various institutions should leverage their expertise to grow India's solar market. For example, certain groups should focus on providing project financing, while others should focus on disseminating information to the market, and others should focus on R&D and skill development. Only when a comprehensive financing strategy is in place will different financial interventions (e.g., priority sector lending, development of the REC market, and infrastructure debt funds) succeed in scaling solar energy investments.

Technology-Neutral Manufacturing: To make domestic manufacturing policies technology-neutral and market-enabling, MNRE could explore the following options: (a) a DCR requiring that all PV modules be manufactured in India, uniformly enforced across all PV technologies; or (b) a DCR specifying that a certain percentage of the solar PV components be manufactured in India; or (c) a preferential incentive to promote domestic manufacturing instead of a DCR to avoid being restrictive and to lessen international controversy.

The National Solar Mission has the potential to transform India's energy sector and help power its rapid economic growth while building a sustainable future. India needs continued government and private sector support, increased investment in manufacturing, and more technology sharing to unleash this potential in the next phase of the Solar Mission. Beyond energy security and environmental imperatives, lessons learned from a successful National Solar Mission could provide a road map for other countries seeking to scale up access to clean, affordable, and sustainable energy worldwide. This report is submitted with the hope that its findings and recommendations can advance implementation in subsequent phases and promote a comprehensive and strategic approach to building a robust grid-connected solar industry in India.

IX. LIST OF STAKEHOLDER ORGANIZATIONS

From September 2011 to March 2012, we held discussions and roundtables with many stakeholders, including the following organizations, to develop this report:

Abhijeet
Abound Solar
Acira Solar Pvt. Ltd.
Alex Spectrum Radiation Pvt. Ltd.
Applied Materials
Arbutus Consultants Pvt. Ltd.
Avantha Power
Axis Bank
Azure Power
Bergen Solar Power & Energy Ltd.
Bridge to India
Carbon War Room
CCCL Infrastructure
Central Electricity Regulatory Commission
Centrotherm Photovoltaic AG
Credit Rating and Information Services of India Ltd.
DDE Renewable Energy Pvt. Ltd.
Energy Alternatives India
Ernst & Young
Feedback Infrastructure Services
FirstSolar, Inc.
GIZ
Global Business Consultants
Green Stratos Consulting Pvt. Ltd.
ICICI Bank
IndenGroup
Indian Oil Corporation
Indian Renewable Energy Development Agency
Indosolar
International Finance Corporation
Intersolar 2011 Participants
Karnataka Power Corporation
KPMG
Kyocera Solar
Lanco Solar Energy Pvt. Ltd.
Larsen & Toubro
Lawrence Berkeley National Laboratory
Maharashtra Seamless
Maharishi Solar
Mahindra Solar One Pvt. Ltd.
Master Consultancy & Productivity Pvt. Ltd.
Ministry of New and Renewable Energy
Moser Baer Clean Energy
Nomura Group
NTPC Vidyut Vyapar Nigam
Office of the U.S. Trade Representative
Oswal Woollen Mills
Precision Technik Pvt. Ltd.
Punj Lloyd Delta Renewables
Rexroth Bosch Group
Rithwik Projects
SEMI
Shakti Sustainable Energy Foundation
Solar Energy Society of India
Solar Semiconductor
SOLARCON 2011 Participants
SolarEdge Technologies
Solaria Corporation
State Bank of India
STEAG Energy Services (India) Pvt. Ltd.
SunEdison Energy Pvt. Ltd.
Tata BP Solar
Umicore
U.S. Department of Commerce
U.S. Department of Energy
U.S. Export-Import Bank
U.S.-India Business Council
U.S. Overseas Private Investment Corp.
Welspun Group
Wolfensohn Capital

Endnotes

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19 Off-grid solar is hugely important in a country like India, where millions have no access to modern sources of energy. However, the mechanisms to provide off-grid solar access will be different from those applicable to the grid-connected sector. Off-grid, therefore, deserves a separate analysis.

20 In addition to creating a conducive environment for solar systems, the Mission's policies help build demand and capacity within the solar sector and shape the rest of the solar ecosystem.

21 In early 2012, Gujarat, Rajasthan, and Karnataka adopted solar policies and are projected to have a cumulative 1,050 MW of solar capacity installed by 2013. See Bridge to India, "The India Solar Handbook," December 13, 2011: bridgetoindia.com/reports ("Bridge to India Report," accessed April 2, 2012).

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25 The primary solar manufacturer categories include solar PV components (e.g., modules, cells); solar thermal equipment (e.g., mirrors, turbines); and the balance of system components (e.g., inverters, heavy electrical equipment, wiring, and power plant hardware).

26 Examples of important R&D efforts include: development of next-generation solar cell technologies to reduce production

costs or increase efficiency, studies of solar irradiance and weather patterns (including dust storms), and advances in routine maintenance (such as cleaning and upkeep of grid connectivity) to strengthen the efficient operation of current and future plants.

27 National policies include the removal of excise duties for certain imports and special incentive package schemes for solar cell manufacturing. State policies include provision of land-use permits to set up solar plants.

28 See Mission Document.

29 See id. Rooftop solar has received limited attention under Phase 1 of the Mission so far. As a locally-accessible source of energy, distributed generation through rooftop solar suffers fewer transmission losses, maintains better grid stability, costs less than large solar plants, and encounters fewer land acquisition barriers. See P.S. Deodhar, "Why Distributed Solar Power is Crucial," *Power Engineering Magazine*, April 5, 2012, http://www.power-eng.com/news/2012/04/04/why-distributed-solar-power-is-crucial.html (accessed April 16, 2012).

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31 MNRE press statement, "Generation of Solar Power," March 19, 2012, pib.nic.in/newsite/pmreleases.aspx?mincode=28 (503.9 MW on March 19, 2012; accessed April 2, 2012); Communication from MNRE, March 26, 2012 (clarifying 3 MW increase to 506.9 MW); Natalie Obiko Pearson, "India Misses Solar Target With 20-Fold Jump in Capacity in Year," *Bloomberg*, January 2012, bloomberg.com/news/2012-01-20/india-misses-solar-target-with-20-fold-jump-in-capacity-in-year.html (17.8 MW in 2010; accessed April 2, 2012).

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